

Hydraulic Drive Apparatus

BACKGROUND OF THE INVENTION

The present invention relates to a hydraulic drive apparatus used for hydraulic shovels, cranes, asphalt finishers, machine tools and the like. More particularly, the invention relates to
5 a hydraulic drive apparatus that controls a pressure of working oil supplied from a hydraulic pump to be higher than a load pressure of a hydraulic motor by a predetermined pressure.

A technique to be described hereunder is known for a hydraulic pressure circuit for controlling an electro-hydraulic
10 servomechanism.

In Fig. 5, reference numeral 1 is an operation lever which inputs a desired operation position by varying an angle of the lever; and 2 is an operation-position signal outputting means which generates a voltage (operation position signal) depending
15 on an input angle of the operation lever 1 and outputs the voltage to a controller 3. The operation position input by the operation lever 1 is converted by the operation-position signal outputting means 2 into the operation position signal to be output to the controller 3.

20 A feedback signal is fed back to the controller 3, from a

speed detector 4 which is attached to an output portion of a hydraulic motor 16 to detects a speed (an output rotational number) of the output portion.

The hydraulic pump 12 feeds working oil from a tank 11 to a hydraulic motor 16. During the flow of the working oil from the tank 11 to the hydraulic motor 16, the working oil is selected in its flow or its flow is controlled by a directional control valve 15. That is, the directional control valve 15 controls an operation of the hydraulic motor 16.

An operation position signal output from the operation-position signal outputting means 2 and a feedback signal output from the speed detector 4 are input the controller 3. The controller 3 compares the input operation position signal with the input feedback signal, and controls the directional control valve 15 so that the hydraulic motor 16 operates in accordance with the operation position that is input by the operation lever 1. Accordingly, the hydraulic motor 16 operates in accordance with the operation position input by the operation lever 1.

A pressure of the working oil supplied from the hydraulic pump 12 is set at a constant value corresponding to the maximum load pressure independently of a quantity of the working oil used by the hydraulic motor 16, by a combination of a pressure-compensating-function-added servo regulator 13 and a relief valve

14. Accordingly, the hydraulic motor 16 is operable for any arbitrary load pressure.

However, the hydraulic drive apparatus discussed above has the following problem. Even if the load pressure to the hydraulic motor 16 is extremely smaller than the pressure of the working oil supplied from the hydraulic pump 12, the pressure of the working oil supplied from the hydraulic pump 12 is always constant. Therefore, the drive horsepower of the hydraulic pump 12 is wastefully consumed.

Accordingly, an object of the present invention is to drive a hydraulic motor without wastefully consuming the drive horsepower of a hydraulic pump.

A hydraulic drive apparatus in which a plurality of hydraulic motors are driven through a plurality of control valves by one hydraulic pump as disclosed in JP-A-11-36374 has been known for the hydraulic drive apparatus used for general purpose construction machines, such a hydraulic shovel.

An example of the arrangement of the hydraulic drive apparatus will be described with reference to an accompanying drawing.

In a hydraulic drive apparatus 500 shown in Fig. 15, when an operation position is input to an operation lever 610, an electric motor 630 is driven and rotated in accordance with the

operation position input to the operation lever 610. The control valve 650 is designed such that when a rotational speed difference is produced between the electric motor 630 and the hydraulic motor 601, the control valve 650 adjusts a quantity of working oil supplied from a hydraulic pump 502 to the hydraulic motor 601 to reduce the speed difference between the electric motor 630 and the hydraulic motor 601 by driving and rotating the hydraulic motor 601. Therefore, when the electric motor 630 is rotated, the hydraulic motor 601 rotates following up the rotation of the electric motor 630, through the action of the control valve 650.

A control valve, such as the control valve 650, which drives and rotates the hydraulic motor in accordance with the rotational speed difference between the electric motor and the hydraulic motor, will be referred to as an electro-hydraulic servovalve.

When the operation position is input to an operation lever 710, an operation oil flows through operation oil passages 711 and 712 in accordance with the operation position input to the operation lever 710, and a control valve 750 changes its valve or spool position by the flow of the operation oil. When the control valve 750 moves its position, a quantity of the working oil supplied from the hydraulic pump 502 to a hydraulic motor 701 is controlled, so that the hydraulic motor 701 is driven and rotated. Such a hydraulic motor as the control valve 750,

exclusive of the electro-hydraulic servovalve, arranged such that it drives and rotates the hydraulic motor in accordance with the operation position input to the operation lever will be referred to as a general purpose valve.

5 Generally, the electro-hydraulic servovalve is higher in control accuracy than the general purpose valve.

 However, the hydraulic drive apparatus 500 mentioned above suffers from the following problem: When an electro-hydraulic servovalve is used as one of the plurality of control valves in
10 order to improve the control accuracy of a specific rotary shaft, it is difficult to simultaneously drive those hydraulic motors.

 For example, in a case of simultaneously driving and rotating the hydraulic motor 601 and the hydraulic motor 701, if a load of the hydraulic motor 701 is smaller than that of the
15 hydraulic motor 601, the working oil supplied from the hydraulic pump 502 flows through the control valve 750 (i.e., the general purpose valve), but does not flow through the control valve 650 (i.e., the electro-hydraulic servovalve). Therefore, the
20 hydraulic motor 701 can be driven and rotated, but the hydraulic motor 601 is not rotated.

 Accordingly, an object of the present invention is to provide a hydraulic drive apparatus which is provided with an electro-hydraulic servovalve and at least one general purpose

valve, and is capable of simultaneously operating a plurality of hydraulic motors.

SUMMARY OF THE INVENTION

The present invention provides the followings:

5 1. A hydraulic drive apparatus for driving and rotating a drive rotary member in accordance with an operation position input from operation position inputting means, the apparatus comprising:

10 a drive rotary member driven and rotated by hydraulic pressure;

 working oil supplying means for supplying working oil to drive and rotate the drive rotary member;

15 rotation control means for controlling a quantity of the working oil supplied from the working oil supplying means to the drive rotary member so that the drive rotary member is driven and rotated as desired, the rotation control means including:

 operation position inputting means for inputting an operation position;

20 operation-position signal outputting means for generating and outputting an operation position signal depending on the operation position input by the operation position inputting means;

 drive signal outputting means for computing and

pressure of the main relief valve by varying a set pressure thereof; and

oil pressure control means for receiving the supplying-oil pressure signal output from the supplying oil detect means and the drive oil pressure signal output from the drive oil pressure detecting means, and outputting a current to the electromagnetic relief valve to vary the set pressure of the electromagnetic relief valve and thus the set pressure of the main relief valve, thereby controlling the pressure of the working oil supplied from the working oil supplying means to be higher, by a predetermined pressure, than the pressure of the working oil for driving and rotating the drive rotary member.

2. A hydraulic drive apparatus according to 1, further comprising:

supplying oil quantity control means for controlling a quantity of the working oil that the working oil supplying means supplies; and

supplying oil quantity signal outputting means for receiving the operation position signal output from the operation-position signal outputting means, generating a supplying oil quantity signal from the input operation position signal, and outputting the supplying oil quantity signal to the supplying oil quantity control means, thereby controlling the

quantity of the working oil supplied to the supplying oil quantity control means by the working oil supplying means.

3. A hydraulic drive apparatus according to 1, wherein the drive oil pressure detecting means includes a pressure gauge for
5 detecting the pressure of the working oil supplied from the working oil control means to the drive rotary member, and another pressure gauge for detecting the pressure of the working oil supplied from the drive rotary member to the working oil control means.

4. A hydraulic drive apparatus according to 1, wherein
10 when the pressure of the working oil detected by the drive oil pressure detecting means is equal to or higher than a predetermined pressure, the oil pressure control means feeds current of a predetermined value to the electromagnetic relief valve.

5. A hydraulic drive apparatus according to 4, further
15 comprising:

a check valve for preventing a reverse flow of the working oil when the working oil whose pressure is regulated to be equal to or lower than the set pressure by the main relief valve is supplied from the working oil supplying means to the working oil
20 control means.

6. A hydraulic drive apparatus according to 1, further comprising:

an additional drive rotary member driven by hydraulic

pressure;

additional rotation control means including:

an additional electric motor driven at a speed and a quantity of rotation depending on the drive signal output from the drive signal outputting means, and

additional working oil control means for receiving from the working oil supplying means the working oil equal in pressure to the working oil supplied from the working oil supplying means to the working oil control means, and controlling a quantity of the working oil supplied from the working oil supplying means to the additional drive rotary member so that the additional drive rotary member is driven and rotated depending on rotation of the additional electric motor; and

additional drive oil pressure detecting means for detecting a pressure of the working oil for driving and rotating the additional drive rotary member, and generating and outputting a drive oil pressure signal depending on the pressure thus detected;

wherein the oil pressure control means receives the supplying-oil pressure signal output from the supplying oil pressure detect means, the drive oil pressure signal output from the drive oil pressure detecting means, and the drive oil pressure signal output from the additional drive oil pressure detecting

means, and outputs the current to the electromagnetic relief valve to vary the set pressure of the electromagnetic relief valve and thus the set pressure of the main relief valve, thereby controlling the pressure of the working oil supplied from the working oil supplying means to be higher, by the predetermined pressure, than a higher one of the pressure of the working oil for driving and rotating the drive rotary member and the pressure of the working oil for driving and rotating the additional drive rotary member.

7. A hydraulic drive apparatus according to 6, wherein the additional rotation control means includes:

additional operation position inputting means for inputting an operation position;

additional operation-position signal outputting means for generating and outputting an operation position signal depending on the operation position input to the additional operation position inputting means; and

additional drive signal outputting means for computing and converting the operation position signal output from the additional operation-position signal outputting means into a drive signal to be output therefrom;

wherein the additional electric motor is driven and rotated at a speed and a quantity of rotation depending on the drive signal output from the additional drive signal outputting means.

8. A hydraulic drive apparatus according to 6, further comprising:

supplying oil quantity control means for controlling a quantity of the working oil that the working oil supplying means
5 supplies; and

supplying oil quantity signal outputting means for receiving the operation position signal output from the operation-position signal outputting means, and the operation position signal output from the additional operation-position
10 signal outputting means, generating the supplying oil quantity signal from the thus input two operation position signals, and outputting the supplying oil quantity signal to the supplying oil quantity control means, thereby allowing the supplying oil quantity control means to control the quantity of the working oil
15 that the working oil supplying means supplies.

9. A hydraulic drive apparatus comprising:

a hydraulic pump for supplying working oil;

a first hydraulic motor supplied with the working oil from the hydraulic pump, and driven and rotated by the supplied working
20 oil;

a first operation unit for driving and rotating the first hydraulic motor, the first operation unit including:

first operation position input means for receiving an

operation position, generating an operation position signal depending on the operation position, and outputting the operation position signal;

drive signal outputting means for receiving the
operation position signal, computing and converting the operation
5 position signal into a drive signal, and outputting the drive
signal;

an electric motor that receives the drive signal and
that is driven and rotated at a rotational speed depending on the
10 drive signal; and

a first control valve, through which the working oil supplied from the hydraulic pump to the first hydraulic motor flows, for controlling a quantity of the working oil flowing therethrough depending on the rotational speeds of the electric motor and the first hydraulic motor, thereby controlling the quantity of the working oil supplied from the hydraulic pump to the first hydraulic motor, wherein the first operation unit drives and rotates the first hydraulic motor depending on the operation position that is input to the first operation position input means;

20 a second hydraulic motor supplied with the working oil from
the hydraulic pump and driven and rotated by the supplied working
oil;

a second operation unit for driving and rotating the second

hydraulic motor, the second operation unit including:

second operation position inputting means for receiving an operation position; and

a second control valve, through which the working oil
5 supplied from the hydraulic pump to the second hydraulic motor flows, for controlling a quantity of the working oil flowing therethrough depending on the operation position that is input to the second operation position inputting means, thereby controlling the quantity of the working oil supplied from the
10 hydraulic pump to the second hydraulic motor, wherein the second operation unit drives and rotates the hydraulic motor in accordance with the operation position input to the second operation position inputting means;

supplying oil pressure detect means for detecting a
15 pressure of the working oil supplied from the hydraulic pump to the first control valve, generating a supplying-oil pressure signal on the pressure thus detected, and outputting the supplying-oil pressure signal;

drive oil pressure detecting means for detecting a pressure
20 of the working oil for driving and rotating the first hydraulic motor, generating a drive oil pressure signal depending on the pressure thus detected, and outputting the drive oil pressure signal;

working oil pressure adjusting means so that the set pressure of the second working oil pressure adjusting means is higher, by a predetermined pressure, than the pressure of the working oil necessary for driving and rotating the first hydraulic motor, wherein when the first operation unit stops the rotation of the first hydraulic motor, the pressure adjust signal outputting means generates a pressure adjust signal for allowing the second working oil pressure adjusting means to adjust the set pressure of the second working oil pressure adjusting means to be a pressure permitting free flow of the working oil, and wherein the pressure adjust signal outputting means outputs the generated pressure adjust signal to the second working oil pressure adjusting mean; wherein the first control valve, the first working oil pressure controlling means, and the second working oil pressure controlling means are arranged so that the pressures of the working oil supplied to the first control valve, the first working oil pressure controlling means, and the second working oil pressure controlling means are equal to each other.

10. A hydraulic drive apparatus according to 9, further comprising:

supplying oil quantity adjusting means for adjusting a quantity of the working oil supplied from the hydraulic pump; operation position detecting means for detecting the

operation position input to the second operation position inputting means, generates an operation position detect signal depending on the operation position thus detected, and outputting the operation position detect signal;

5 supplying oil quantity adjusting signal outputting means for receiving the operation position signal and the operation position detect signal, generating a supplying oil quantity adjust signal for allowing the supplying oil quantity means to adjust the quantity of working oil that the hydraulic
10 pump supplies depending on the operation position signal and operation position detect signal, and outputting the supplying oil quantity adjust signal to the supplying oil quantity adjusting means,

wherein the supplying oil quantity adjusting signal
15 outputting means judges whether the second operation unit drives and rotates the second hydraulic motor or stops the rotation of the second hydraulic motor,

wherein when the second operation unit drives and rotates the second hydraulic motor, the supplying oil quantity adjusting
20 signal outputting means generates the supplying oil quantity adjust signal so that the quantity of the working oil that the hydraulic pump supplies is a predetermined quantity,

wherein when the second operation unit stops the rotation

of the second hydraulic motor, the supplying oil quantity
adjusting signal outputting means computes the quantity of the
working oil necessary for driving and rotating the first hydraulic
motor depending on the operation position signal, and generates
5 the supplying oil quantity adjust signal so that the quantity
of the working oil that the hydraulic pump supplies is larger,
by a predetermined quantity, than the quantity of the working oil
necessary for driving and rotating the first hydraulic motor.

11. A hydraulic drive apparatus according to 10, wherein:
10 the second control valve controls the quantity of the working
oil flowing therethrough depending on the operation position
input to the second operation position inputting means in such
a manner that the second operation position inputting means
supplies an operation oil that is for operating the second control
15 valve, and that depends in quantify on the input operation position,
and the second control valve receives the operation oil from the
second operation position inputting means to adjust the quantity
of the working oil flowing therethrough depending on the quantity
of the operation oil; and

20 the operation position detecting means detects a pressure
of the operation oil supplied from the second operation position
inputting means to the second control valve to detect the operation
position input to the second operation position inputting means.

12. A hydraulic drive apparatus according to 9, further comprising:

at least one or more number of additional hydraulic motors receiving the working oil from the hydraulic pump to be driven and rotated by the working oil supplied;

at least one or more number of additional operation units, equal in number to the additional hydraulic motors, for driving and rotating the additional hydraulic motors;

wherein the additional operation unit includes:

additional operation position inputting means to which operation positions are input; and

additional control valves, through which the working oil supplied from the hydraulic pump to the respective additional hydraulic motors flows therethrough, for adjusting a quantity of the working oil flowing therethrough depending on the respective operation positions input to the additional operation position inputting means, thereby adjusting the quantity of the working oil supplied from the hydraulic pump to the respective additional hydraulic motors;

wherein the additional operation unit drives and rotates the additional hydraulic motors depending on the operation position input to the additional operation position inputting means;

wherein the second working oil pressure adjusting means

allows the working oil supplied from the hydraulic pump to the additional control valves to flow therethrough, and adjusts a pressure of the working oil flowing therethrough.

13. A hydraulic drive apparatus according to 12, wherein
5 the additional control valves and the second control valve are arranged so that the pressures of the working oil supplied to the additional control valves and the second control valve are equal to each other.

14. A hydraulic drive apparatus according to 12, wherein
10 the additional control valves and the second control valve are arranged so that the working oil supplied to the additional control valves is the working oil having flowed through the second control valve.

15. A hydraulic drive apparatus according to any of 12 to
15 14, further comprising:

supplying oil quantity adjusting means for adjusting a quantity of the working oil that the hydraulic pump supplies;

operation position detecting means which detects an
operation position to be input to one of different ones of the
20 second operation position inputting means and the additional operation position inputting means, and generates and outputs an operation position detect signal in accordance with the operation position, the number of the operation position detecting means

being equal to a total number of the second operation position inputting means and the additional operation position inputting mean; and

supplying oil quantity adjusting signal outputting means
5 which receives the operation position signal and the operation position detect signal, generates a supplying oil quantity adjust signal for causing the supplying oil quantity adjusting means to adjust a quantity of the working oil that the hydraulic pump supplies depending on the operation position signal and the
10 operation position detect signal, whereby the supplying oil quantity adjusting signal outputting means outputs the supplying-oil quantity adjust signal to the supplying oil quantity adjusting means;

wherein the supplying oil quantity adjusting signal
15 outputting means judges, from the operation position detect signal, whether at least one of the second operation unit and the additional operation units drive and rotate one of the second hydraulic motor and the additional hydraulic motors or whether all of the second operation unit and the additional operation units
20 stop the rotation of all of the second hydraulic motor and the additional hydraulic motors,

wherein when at least one of the second operation unit and the additional operation units drive and rotate one of the second

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hydraulic motor and the additional hydraulic motors, the
supplying oil quantity adjusting signal outputting means
generates the supplying-oil adjust signal so that a quantity of
working oil that the hydraulic pump supplies is equal to a maximum
5 oil quantity of the hydraulic pump,

wherein when all of the second operation unit and the
additional operation units stop the rotation of all of the second
hydraulic motor and the additional hydraulic motors, the
supplying oil quantity adjusting signal outputting means computes
10 a quantity of working oil necessary for driving and rotating the
first hydraulic motor depending on the operation position signal,
and generates the supplying oil quantity adjust signal so that
a quantity of working oil that the hydraulic pump supplies is
larger, by a predetermined quantity, than a quantity of working
15 oil necessary for driving and rotating the first hydraulic motor.

16. A hydraulic drive apparatus according to 15, wherein
the second control valve and the additional control valves control
quantities of the working oil flowing therethrough depending on
the operation positions input to the second operation position
20 inputting means and the additional operation position inputting
means in a manner that the second operation position inputting
means and the additional operation position inputting means
supply operation oil for operating the second control valve and

the additional control valves depending in quantity on the input operation positions, the second control valve and the additional control valves are supplied with the operation oil from the second operation position inputting means and the additional operation position inputting means, and adjusts the quantities of the working oil flowing therethrough depending on the quantities of the operation oil supplied, and

a plurality of the operation position detecting means detect pressures of the operation oil supplied to the second control valve and the additional control valves from the second operation position inputting means and the additional operation position inputting means, detect operation positions input to the second operation position inputting means and the additional operation position inputting means by generating and outputting operation oil pressure signals depending on the pressures, and generate and output a plurality of operation position detect signals depending on the operation positions.

17. A hydraulic drive apparatus according to any of 9 to 15, wherein the second working oil pressure adjusting means includes an electromagnetic relief valve which adjusts the pressure of the working oil supplied from the hydraulic pump to the first control valve to be equal to or lower than the set pressure by causing the working oil supplied from the hydraulic

hydraulic motor,

wherein the first operation unit includes

first operation position input means which receives a operation position and generates and outputs an operation position signal

5 dependent on the operation position, drive signal outputting means which receives the operation position signal, and computes the operation position signal to produce and output a drive signal,

and an electric motor being driven and rotated at a rotational speed dependent on the drive signal input thereto, and a first

10 control valve which causes the working oil supplied from the hydraulic pump to the first hydraulic motor, and adjusts a quantity of the working oil supplied from the hydraulic pump to the

hydraulic motor by adjusting a quantity of the working oil caused to flow in accordance with the electric motor and the first

15 hydraulic motor, whereby the first operation unit drives and rotates the first hydraulic motor in accordance with an operation position input to the first operation position input means,

the second operation unit includes second operation position inputting means for receiving an operation position, and a second

20 control valve which causes working oil supplied from the hydraulic pump to the second hydraulic motor to flow, and adjusts a quantity of the working oil supplied from the hydraulic pump to the second hydraulic motor by adjusting a quantity of the working oil caused

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to flow in accordance with an operation position input to the second operation position inputting means, whereby the second hydraulic motor is driven and rotated in accordance with the operation position input to the second operation position

5 inputting means,

the hydraulic drive apparatus further comprising:

supplying oil detect means which detects a pressure of the working oil supplied from the hydraulic pump to the first control valve, and generates and outputs a supplying-oil pressure signal
10 dependent on the pressure;

drive oil pressure detecting means which detects a pressure of the working oil for driving and rotating the first hydraulic motor, and generates and outputs a drive oil pressure signal dependent on the pressure;

15 working oil pressure adjusting means which receives working oil from the hydraulic pump and causes the working oil supplied to flow, and adjust a pressure of the working oil supplied from the hydraulic pump to the first control valve to be below a set pressure of the working oil;

20 supplying oil quantity adjusting means for adjusting a quantity of the working oil supplied from the hydraulic pump;

working oil quantity adjust means which causes the working oil supplied from the hydraulic pump to the second control valve

to flow, and adjusts a quantity of the working oil caused to flow;

operation position detecting means which detects an operation position input to the second operation position inputting means and generates and outputs an operation position
5 detect signal which depends on the operation position; and

oil quantity adjust signal outputting means which receives the operation position signal and the operation position detect signal, and judges from the operation position detect signal as input whether the second operation unit drives and rotates the
10 second hydraulic motor or stops the rotation of the second hydraulic motor, when the second operation unit stops the rotation of the second hydraulic motor, oil quantity adjust signal

outputting means computes a quantity of the working oil necessary for driving and rotating the first hydraulic motor by use of the operation position signal, generates a working oil quantity
15 adjust signal for causing the working oil quantity adjust means to a quantity of the working oil caused to flow by the working oil quantity adjust means so that the working oil caused to flow by the working oil quantity adjust means has a quantity of oil

relative to a quantity of of the working oil necessary for driving and rotating the first hydraulic motor, and generates a working-oil quantity adjust signal for causing the supplying oil quantity adjusting means to adjust a quantity of the working oil
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supplied from the hydraulic pump in order that a quantity of the working oil that the hydraulic pump supplies is larger than a quantity of the working oil necessary for driving and rotating the first hydraulic motor by a predetermined quantity of oil, when
5 the second operation unit drives and rotates the second hydraulic motor, the oil quantity adjust signal outputting means generates the working-oil quantity adjust signal so that the working oil quantity adjust means flows working oil freely, generates the supplying-oil quantity adjust signal so that the working oil
10 supplied by the hydraulic pump has a predetermined quantity of oil, outputs the working-oil quantity adjust signal generated to the working oil quantity adjust means, and outputs the supplying-oil adjust signal generated to the supplying oil quantity adjusting means;

15 wherein the first control valve, the working oil pressure adjusting means and the working oil quantity adjust means are arranged such that the pressures of the working oil supplied to the first control valve, the working oil pressure adjusting means and the working oil quantity adjust means are equal to one another.

20 20. A hydraulic drive apparatus according to 19, wherein the second control valve adjusts a quantity of the working oil caused to flow in accordance with an operation position input to the second operation position inputting means in a manner that

the second operation position inputting means supplies the operation oil for operating the second control valve, a quantity of the operation oil being dependent on a quantity of the operation position as input, and the second control valve is supplied with the operation oil from the second operation position inputting means and adjusts a quantity of the working oil caused to flow in accordance with the operation oil caused to flow, and the operation position detecting means detects a pressure of the operation oil supplied from the second operation position inputting means to the second control valve, detects an operation position input to the second operation position inputting means by generating and outputting an operation oil pressure signal dependent on the pressure, and generates and outputs an operation position detect signal dependent on the operation position.

21. A hydraulic drive apparatus according to 19 or 20, further comprising pressure adjust signal outputting means which receives the supplying-oil pressure signal, the drive oil pressure signal, and the operation position detect signal, judges from the operation position detect signal as input whether the second operation unit drives and rotates the second hydraulic motor or stops the rotation the second hydraulic motor, when the second operation unit stops the rotation of the second hydraulic motor, the pressure adjust signal outputting means computes a

pressure of the working oil for driving and rotating the first hydraulic motor by use of the supplying-oil pressure signal and the drive oil pressure signal, and generates a pressure adjust signal for causing the working oil pressure adjusting means to adjust a set pressure of the working oil pressure adjusting means so that the set pressure of the working oil pressure adjusting means is higher than a pressure of the working oil necessary for driving and rotating the first hydraulic motor by a predetermined value of pressure, when the second operation unit drives and rotates the second hydraulic motor, the pressure adjust signal outputting means generates a pressure adjust signal for causing the working oil pressure adjusting means to adjust a set pressure of the working oil pressure adjusting means so that a set pressure of the working oil pressure adjusting means reaches a predetermined pressure in value, and outputs the pressure adjust signal generated to the working oil pressure adjusting means.

22. A hydraulic drive apparatus comprising:

hydraulic pump for supplying working oil,

a first hydraulic motor being driven and rotated by the working oil received from the hydraulic pump when operated,

a first operation unit for driving and rotating the first hydraulic motor,

a second hydraulic motor being driven and rotated by the

working oil received from the hydraulic pump,

a second operation unit for driving and rotating the second hydraulic motor,

at least one or more number of additional hydraulic motors
5 being driven and rotated by the working oil received from the hydraulic pump, and

additional operation units for driving and rotating
the additional hydraulic motor, the number of the additional
operation units being equal to that of the additional hydraulic
10 motors,

wherein the first operation unit includes

first operation position input means for generating an
operation position signal in accordance with an operation
position input thereto,

15 drive signal outputting means for computing the operation position signal input thereto into a drive signal and outputting the same,

an electric motor being driven and rotated at a rotational speed dependent on the drive signal input thereto, and

20 a first control valve for adjusting a quantity of the working oil supplied from the hydraulic pump to the first hydraulic motor by causing the working oil supplied from the hydraulic pump to the first hydraulic motor to flow and adjusting a quantity of the

working oil caused to flow in accordance with the rotational speeds of the electric motor and the first hydraulic motor,

whereby the first hydraulic motor is driven and rotated in accordance with an operation position input to the first operation position input mean,

the second operation unit includes second operation position inputting means to which an operation position is input, and

a second control valve for adjusting a quantity of the working oil supplied from the hydraulic pump to the second hydraulic motor by causing the working oil supplied from the hydraulic pump to the second hydraulic motor and adjusting a quantity of the working oil caused to flow in accordance with an operation position input to the second operation position inputting means, whereby the second hydraulic motor is driven and rotated in accordance with the second operation position inputting means,

the additional operation units each includes additional operation position inputting means to which an operation position is input, and an additional control valve for adjusting a quantity of the working oil supplied from the hydraulic pump to the additional hydraulic motor by causing the working oil supplied from the hydraulic pump to the additional hydraulic motor to flow, and adjusting a quantity of the working oil caused to flow in accordance with an operation position input to the additional

operation position inputting means, and whereby the additional hydraulic motor is driven and rotated by an operation position input to the additional operation position inputting means, the hydraulic drive apparatus further comprising:

5 supplying oil detect means which detects a pressure of the working oil supplied from the hydraulic pump to the first control valve, and generates and outputs a supplying-oil pressure signal dependent on the pressure;

10 drive oil pressure detecting means which detects a pressure of the working oil for driving and rotating the first hydraulic motor, and generates and outputs a drive oil pressure signal dependent on the pressure;

15 working oil pressure adjusting means for adjusting a pressure of the working oil supplied from the hydraulic pump to the first control valve by causing the working oil supplied from the hydraulic pump to flow;

supplying oil quantity adjusting means for adjusting a quantity of the working oil that the hydraulic pump supplies;

20 working oil quantity adjust means which causes the working oil supplied from the hydraulic pump to the second control valve and the working oil supplied from the hydraulic pump to the additional control valve to flow, and adjusts a quantity of the working oil caused to flow;

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a plurality of operation position detecting means which detects operation positions input to the second operation position inputting means and the additional operation position inputting means, and generates and outputs an operation position
5 detect signal in accordance with the operation positions; and

oil quantity adjust signal outputting means which receives the operation position signal and the operation position detect signal, and judges from the operation position detect signal as input whether the second operation unit and at least one of the
10 additional operation units drive and rotate any of the second hydraulic motor and the additional hydraulic motors or the second operation unit and the additional operation units stop the rotation of the second hydraulic motor and the additional hydraulic motors, when the second operation unit and all of the
15 additional operation units stop the second hydraulic motor and the additional hydraulic motors, the oil quantity adjust signal outputting means computes a quantity of working oil necessary for driving and rotating the first hydraulic motor by use of the operation position signal, and generates a working oil quantity
20 adjust signal for causing the working oil quantity adjust means to adjust a quantity of the working oil caused to flow by the working oil quantity adjust means in order that the working oil caused to flow by the working oil quantity adjust means has a

predetermined quantity relative to the quantity of the working oil necessary for driving and rotating the first hydraulic motor, generates a supplying-oil adjust signal for causing the supplying oil quantity adjusting means to adjust a quantity of the working oil that a quantity of the hydraulic pump supplies so that the working oil that the hydraulic pump supplies is larger than the quantity of the working oil necessary for driving and rotating the first hydraulic motor by a predetermined quantity, when the second operation unit and at least one of the additional operation units drive and rotate any of the second hydraulic motor and the additional hydraulic motors, the oil quantity adjust signal outputting means generates the working oil quantity adjust signal so that the working oil quantity adjust means causes the working oil to flow freely, generates the supplying-oil adjust signal so that a quantity of the working oil that the hydraulic pump supplies reaches a predetermined quantity, and oil quantity adjust signal outputting means for outputting the working oil quantity adjust signal generated to the working oil quantity adjust means and the supplying-oil adjust signal generated to the supplying oil quantity adjusting means;

wherein the first control valve, the working oil pressure adjusting means, and the working oil quantity adjust means are arranged so that the quantities of the working oil fed to the first

control valve, the working oil pressure adjusting means, and the working oil quantity adjust means are equal to one another.

23. A hydraulic drive apparatus according to 22, wherein the additional control valve and the second control valve are arranged so that the quantities of the working oil fed to the additional control valve and the second control valve are equal to one another.

24. A hydraulic drive apparatus according to 22, wherein the additional control valve and the second control valve are arranged such that the working oil supplied to the additional control valve is the working oil having flowed through the second control valve.

25. A hydraulic drive apparatus according to any of 22 to 24, wherein the second control valve and the additional control valve adjusts a quantity of the working oil caused to flow in accordance with an operation position input to the second operation position inputting means and the additional operation position inputting means in a manner that the second operation position inputting means and the additional operation position inputting means supply operation oil for operating the second control valve and the additional control valve, a quantity of the operation oil being dependent on an operation oil as input, receive the operation oil from the second operation position

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inputting means and the additional operation position inputting means, and adjust a quantity of the working oil caused to flow in accordance with a quantity of the operation oil supplied, and the operation position detecting means detects a pressure of an operation oil supplied from the second operation position inputting means and the additional operation position inputting means to the second control valve and the additional control valve, and detects an operation position input to the second operation position inputting means and the additional operation position inputting means by generating and outputting an operation oil pressure signal that is dependent on the pressure.

26. A hydraulic drive apparatus according to any of 22 to 25, further comprising:

pressure adjust signal outputting means receives the supplying-oil pressure signal, the drive oil pressure signal, and the operation position detect signal, and judges from the operation position detect signals as input whether the second operation unit and at least one of the additional operation units drive and rotate any of the second hydraulic motor and the additional hydraulic motors or the second operation unit and all of the additional operation units stop the rotation of the second hydraulic motor and the additional hydraulic motors, when the second operation unit and all of the additional operation units

stop the rotation of the second hydraulic motor and the additional hydraulic motors, the pressure adjust signal outputting means computes a pressure of the working oil necessary for driving and rotating the first hydraulic motor by use of the supplying-oil pressure signal and the drive oil pressure signal, generates a pressure adjust signal for causing the working oil pressure adjusting means to adjust a set pressure of the working oil pressure adjusting means so that the set pressure of the working oil pressure adjusting means is higher than a predetermined pressure of the working oil necessary for driving and rotating the first hydraulic motor, when the second operation unit and at least one of the additional operation units drive any of the second hydraulic motor and the additional hydraulic motor, the pressure adjust signal outputting means generates a pressure adjust signal for causing the working oil pressure adjusting means to adjust a set pressure of the working oil pressure adjusting means so that the set pressure of the working oil pressure adjusting means reaches a predetermined pressure, and outputs the pressure adjust signal generated to the working oil pressure adjusting means.

27. A hydraulic drive apparatus according to 21 or 26, wherein the working oil pressure adjusting means adjusts a pressure of the working oil supplied from the hydraulic pump to

the first control valve to be below a set pressure by causing the working oil supplied from the hydraulic pump to flow, and adjusts the set pressure in accordance with the pressure adjust signal input thereto.

- 5 28. A hydraulic drive apparatus according to 21 or 26, wherein the working oil pressure adjusting means includes a main relief valve for adjusting a pressure of the working oil supplied from the hydraulic pump to the first control valve to be below the set pressure by causing the working oil supplied from the hydraulic pump to flow, and an electromagnetic relief valve for
10 adjusting a set pressure of the main relief valve by adjusting the set pressure in accordance with the pressure adjust signal input thereto.

- 15 The hydraulic drive apparatus of the item 1 of the invention is capable of setting the pressure of the working oil supplied from the hydraulic pump to be a predetermined pressure higher than a load pressure to the hydraulic motor. Therefore, the hydraulic motor may be driven while being free from the wasteful consumption of the drive horsepower of the hydraulic pump.

- 20 The hydraulic drive apparatus of the item 2 is capable of controlling a quantity of the working oil that the working oil supplying means supplies in a quick response manner. Therefore, less flow loss is ensured. Further, the apparatus is capable of

remotely controlling a quantity of the working oil that the working oil supplying means supplies.

The hydraulic drive apparatus of the item 3 is capable of accurately detecting a load pressure of the drive rotary member
5 independently of the direction of the load pressure.

The hydraulic drive apparatus of the item 4 may put the main relief valve in an unloading state to such an extend that no cavitation occurs in the working oil supplied to the drive rotary member when the drive rotary member is forcibly driven and rotated
10 by an external load. This feature of the invention eliminates the wasteful consumption of the drive horsepower of the hydraulic pump.

Where the hydraulic drive apparatus of the item 5 is used, if the main relief valve is put in an unloading state, the drive
15 rotary member will never operate uncontrollably. Therefore, the drive horsepower of the hydraulic pump is not wastefully consumed.

Where a plurality of hydraulic motors are communicatively coupled in parallel to one hydraulic pump, the drive apparatus of the item 6 may set the pressure of the working oil supplied
20 from the hydraulic pump to be a predetermined pressure higher than the load pressure of the pump which is the highest of the load pressures of those hydraulic pumps. Therefore, the hydraulic motor may be driven and rotated not wastefully consuming the drive

horsepower of the hydraulic pump.

Where the hydraulic drive apparatus of the item 7 is used, when a plurality of operation position inputting means is communicatively coupled in parallel to a single hydraulic pump, the pressure of the working oil supplied from the hydraulic pump may be set to be a predetermined pressure higher than the load pressure of the hydraulic motor which is the highest of the pressures of those hydraulic motors. Therefore, the hydraulic motor may be driven and rotated not wastefully consuming the drive horsepower of the hydraulic pump.

The hydraulic drive apparatus of the item 8 is capable of controlling a quantity of the working oil that the working oil supplying means supplies in high response manner. This feature leads to reduction of the flow loss. Further, it can control a quantity of the working oil that the working oil supplying means supplies, remotely.

The hydraulic drive apparatus of each of the items 9, 12, 21 and 26, is capable of compensating for a pressure of the working oil supplied to the electro-hydraulic servovalve. The hydraulic drive apparatus includes at least one electro-hydraulic servovalve. Further, it is able to simultaneously operate a plurality of hydraulic motors.

The hydraulic drive apparatus of each of the items 10, 15,

19 and 22 is capable of compensating for a quantity of the working oil supplied to the electro-hydraulic servovalve. The hydraulic drive apparatus includes an electro-hydraulic servovalve and at least one general purpose valve. Further, it is able to
5 simultaneously operate a plurality of hydraulic motors.

The hydraulic drive apparatus of each of the items 11, 16, 20 and 25 is capable of easily detect an operation position that is input to an operation lever in order to operate the general purpose valve. The hydraulic drive apparatus includes an
10 electro-hydraulic servovalve and at least one general purpose valve. Further, it is able to simultaneously operate a plurality of hydraulic motors.

The hydraulic drive apparatus of each of the items 13 and 23 is able to simultaneously a hydraulic motor driven and rotated
15 by the working oil flowing through an electro-hydraulic servovalve, and all of the plurality of the hydraulic motors driven and rotated by the working oil flowing through the plurality of general purpose valves.

The hydraulic drive apparatus of each of the items 14 and
20 24 is able to simultaneously operate the hydraulic motor driven and rotated by the working oil flowing through the electro-hydraulic servovalve and any one of the hydraulic motors driven and rotated by the working oil flowing through the plurality of

the general purpose valves.

The hydraulic drive apparatus of each of the items 17, 18, 27 and 28 includes at least one general purpose valve which is capable of compensating for a pressure of the working oil supplied to the electro-hydraulic servovalve, and is able to simultaneously operate the plurality of the hydraulic motors.

The present disclosure relates to the subject matter contained in Japanese patent application Nos. Hei. 11-246183 (filed on August 31, 1999), 2000-007386 (filed on January 17, 2000) and 2000-004948 (filed on January 13, 2000), which are expressly incorporated herein by reference in their entireties.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a first embodiment of the present invention.

Fig. 2 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a second embodiment of the present invention.

Fig. 3 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a third embodiment of the present invention.

Fig. 4 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a fourth embodiment of the

present invention.

Fig. 5 is a hydraulic pressure circuit diagram showing a related hydraulic drive apparatus.

Fig. 6 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a fifth embodiment.

Fig. 7 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a sixth embodiment.

Fig. 8 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a seventh embodiment.

Fig. 9 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes an eighth embodiment.

Fig. 10 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a ninth embodiment.

Fig. 11 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a tenth embodiment.

Fig. 12 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes an eleventh embodiment.

Fig. 13 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a twelfth embodiment.

Fig. 14 is hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a thirteenth embodiment.

Fig. 15 is hydraulic pressure circuit diagram showing a related hydraulic drive apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiments of the present invention will be described with reference to the accompanying drawings.

<First Embodiment>

Fig. 1 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which constitutes a first embodiment of the present invention.

10 An arrangement of the hydraulic drive apparatus of the embodiment will first be described.

In Fig. 1, reference numeral 41 designates a tank for storing oil; 43 is a hydraulic motor as a drive rotary member driven and rotated by hydraulic pressure; and 42 is a hydraulic pump as
15 working oil supplying means for driving and rotating the hydraulic motor 43.

Reference numeral 20 designates a rotation control means which controls a quantity of the working oil supplied from the hydraulic pump 42, and supplies the quantity controlled working
20 oil to the hydraulic motor 43, thereby driving the hydraulic motor 43 at a desired rotational speed. The rotation control means 20 is made up of an operation lever 21 as operation position inputting means to which an operation position is input, an operation-

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position signal outputting means 22 for generating and outputting an operation position signal, which is dependent on the operation position input to the operation lever 21, a drive signal output circuit 23A as drive signal outputting means for computing the
5 operation position signal output from the operation-position signal outputting means 22 into a drive signal, and outputting the drive signal, an electric motor 24 as an electrically driven motor being driven and rotated in accordance with a speed and a quantity of rotation, both being defined by the drive signal output
10 from the drive signal output circuit 23A, and a directional control valve 25 as working oil control means which drives and rotates the hydraulic motor 43 in accordance with a rotation of the electric motor 24 by controlling a quantity of the working oil supplied from the hydraulic pump 42 and supplying the
15 quantity-controlled working oil to the hydraulic motor 43.

The directional control valve 25 and the hydraulic motor 43 are coupled together by screw means in order to vary an opening degree of the valve in accordance with a speed difference between the hydraulic motor 43 and the electric motor 24.

20 Reference numeral 45 designates an main relief valve which regulates a hydraulic pressure of the working oil, which is supplied from the hydraulic pump 42 to the directional control valve 25, to be a set pressure or lower. Reference numeral 46

designates an electromagnetic relief valve for varying the set pressure of the main relief valve 45 by varying a set pressure thereof.

Reference numerals 47 and 48 are pressure gauges as drive
5 oil pressure detecting means. Each of those pressure gauges detects a pressure of the working oil for driving and rotating the hydraulic motor 43, and generates a drive oil pressure signal depending on the detected pressure. Reference numeral 49 is a pressure gauge as supply oil pressure detecting means, which
10 detects a pressure of the working oil supplied from the hydraulic pump 42 to the directional control valve 25, and generates and outputs a supplying-oil pressure signal depending on the detected pressure.

Reference numeral 50 is a check valve for preventing the
15 reverse flow of the working oil, and reference numeral 51 is a pump regulator as supplying oil quantity control means, which controls a quantity of the working oil supplied by the hydraulic pump 42.

Reference numeral 23B is an oil pressure control circuit
20 as oil pressure control means. The oil pressure control circuit 22B receives a supplying-oil pressure signal output from the pressure gauge 49 and drive oil pressure signals output from the pressure gauges 47 and 48. The oil pressure control circuit 22B

feeds current to the electromagnetic relief valve 46 to vary a set pressure of the electromagnetic relief valve 46 to thereby vary a set pressure of the main relief valve 45. Consequently, the oil pressure control circuit 22B executes such a control that

5 the pressure of the working oil supplied from the hydraulic pump 42 is higher, by a predetermined pressure, than the pressure of the working oil for driving and rotating the hydraulic motor 43.

Reference numeral 23C is a supplying oil quantity signal output circuit as supplying oil quantity signal outputting means which

10 computes an operation position signal output from the operation-position signal outputting means 22 into a supplying oil quantity signal and outputs it. Incidentally, the drive signal output circuit 23A, the oil pressure control circuit 23B and the supplying oil quantity signal output circuit 23C are

15 accommodated in a housing 23.

Reference numerals 31 to 37 designate signal transmission paths; reference numerals 61 to 66 are oil passages; and numeral 67 is a pilot oil passage.

An operation of the thus constructed hydraulic drive

20 apparatus of the embodiment will be described.

Description will be given about an operation of the hydraulic drive apparatus to drive and rotate the hydraulic motor 43 in accordance with an operation position input by the operation lever

21.

An operator changes an angle of the operation lever 21 to input an operation position to the hydraulic drive apparatus.

Then, the operation-position signal outputting means 22 outputs an operation position signal as an electric signal, which is dependent on the operation position input to the operation lever

21. Subsequently, the operation position signal output from the operation-position signal outputting means 22 is input to the

drive signal output circuit 23A by way of the signal transmission path 31. Upon receipt of the signal, the drive signal output

circuit 23A computes the operation position signal received from the operation-position signal outputting means 22, and outputs

a drive signal to the electric motor 24. The drive signal output from the drive signal output circuit 23A is then input to the

electric motor 24 via the signal transmission path 32. As a result, the electric motor 24 is driven and rotated at a speed and a

quantity of rotation, which are defined by the drive signal received from the drive signal output circuit 23A.

The electric motor 24, directional control valve 25 and hydraulic motor 43 make up an electro-hydraulic servomechanism,

not shown. Therefore, the hydraulic motor 43 is rotated following up the rotation of the electric motor 24.

Description will be given about an operation of the

electro-hydraulic servomechanism, which is made up of the electric motor 24, directional control valve 25 and hydraulic motor 43.

When an angle difference θ_3 is produced between an input angle θ_1 of the electric motor 24 and an output angle θ_2 of the hydraulic motor 43, a mechanical mechanism (not shown) opens a port of the directional control valve 25 in accordance with the angle difference θ_3 . When the port of the directional control valve 25 is opened, the working oil is supplied from the hydraulic pump 42 to the hydraulic motor 43 and the hydraulic motor 43 is driven and rotated since the working oil for driving and rotating the hydraulic motor 43 has been fed from the tank 41 to the directional control valve 25 through the oil passages 61 to 63 by the hydraulic pump 42. When the hydraulic motor 43 is driven and rotated, the mechanical mechanism (not shown) reduces the angle difference θ_3 . When the input angle θ_1 is larger than the output angle θ_2 , the output angle θ_2 is increased through the rotation of the hydraulic motor 43 till the angle difference θ_3 is reduced to zero. When the input angle θ_2 is larger than the output angle θ_1 , the output angle θ_1 is reduced through the rotation of the hydraulic motor 43 till it is reduced to zero.

Accordingly, so long as the angle difference θ_3 is present, the hydraulic motor 43 is driven and rotated by the servomechanism, while following up the rotation of the electric motor 24.

As described above, the electric motor 24 is driven and rotated in accordance with the operation position that is input by operating the operation lever 21 by the operator, and the hydraulic motor 43 is driven and rotated following up the rotation of the electric motor 24. Accordingly, the hydraulic motor 43 is driven and rotated in accordance with the operation position that is input through the operation lever 21 by the operator.

An operation of a featured portion of the present invention will be described.

The working oil for driving and rotating the hydraulic motor 43 by the hydraulic pump 42 is supplied from the tank 41 to the directional control valve 25 through the oil passages 61 to 63.

The working oil that is supplied to the directional control valve 25 is supplied through an oil passage 64 to the hydraulic motor 43 by the directional control valve 25, and thereafter it is returned to the directional control valve 25 via an oil passage 65, or it is supplied through the oil passage 65 to the hydraulic motor 43, and then it is returned to the directional control valve 25 via the oil passage 64, or it is not supplied to the hydraulic motor 43 since its passage connected to the hydraulic motor 43

supplying-oil pressure signal is generated by the pressure gauges
49 depending on a pressure of the working oil in an oil passage
63, which is detected by the pressure gauge 49.

The oil pressure control circuit 23B feeds current to the
5 electromagnetic relief valve 46 through a signal transmission
path 36.

The oil pressure control circuit 23B varies a pressure of the working oil supplied from the hydraulic pump 42 to the directional control valve 25 in the following way by varying the current output therefrom.

When the oil pressure control circuit 23B varies the current that is output through the signal transmission path 36 to the electromagnetic relief valve 46, a set pressure of the electromagnetic relief valve 46 varies since the set pressure of the electromagnetic relief valve 46 varies since the set pressure of the
15 the electromagnetic relief valve 46 is determined by the current input thereto. Since the pressure of the pilot oil in the pilot oil passage 67 is equal to the set pressure in the electromagnetic relief valve 46, the pressure of the pilot oil also varies with variation of the set pressure of the electromagnetic relief valve
20 46. The set pressure of the main relief valve 45 is determined by the pressure of the pilot oil. Therefore, when the pressure of the pilot oil varies, the set pressure of the main relief valve 45 also varies. Further, the main relief valve 45 controls the

pressure of the working oil that is supplied from the hydraulic pump 42 to the directional control valve 25 to be the set pressure or lower. When the set pressure of the main relief valve 45 varies, the pressure of the working oil supplied from the hydraulic pump 42 to the directional control valve 25 also varies.

As described above, the oil pressure control circuit 23B is able to vary the pressure of the working oil supplied from the hydraulic pump 42 to the directional control valve 25 by varying the current fed to the electromagnetic relief valve 46.

Then, the control for the working oil that is supplied from the hydraulic pump 42 to the directional control valve 25 will be described while tracing its control phases.

The pressures of the working oils flowing through the oil passages 64 and 65 are detected by the pressure gauges 47 and 48, respectively; the drive oil pressure signals representative of those detected pressures are generated; and those signals are output to the oil pressure control circuit 23B through the signal transmission paths 33 and 34. The pressure of the working oil in the oil passage 63 is detected by the pressure gauge 49; a supplying-oil pressure signal representative of the detected pressure is generated; and the signal is output to the oil pressure control circuit 23B through the signal transmission path 35.

The oil pressure control circuit 23B receives a

supplying-oil pressure signal from the pressure gauge 49, and drive oil pressure signals from the pressure gauges 47 and 48.

Then, by using a higher one of the drive oil pressure signals (i.e. the drive signal output from the pressure gauge 47 or 48 which detects a pressure higher than that detected by the other pressure gauge 47 or 48) and the supplying-oil pressure signal of the pressure gauge 49, the oil pressure control circuit 23B determines the current to be fed to the electromagnetic relief valve 46 so that the pressure of the working oil received from the hydraulic pump 42 is higher than the pressure of the working oil for driving and rotating the hydraulic motor 43 by 20kg/cm² at maximum. Then, the oil pressure control circuit feeds the current to the electromagnetic relief valve 46 through the signal transmission path 36. By using this current, as described above, the oil pressure control circuit 23B varies the pressure of the working oil supplied from the hydraulic pump 42 to the directional control valve 25.

The reason why the drive oil pressure signal indicative of a higher pressure is selected from the drive oil pressure signals output from the pressure gauges 47 and 48 when the oil pressure control circuit 23B determines the current to be fed to the electromagnetic relief valve 46 is that a higher one of the hydraulic pressures detected by the pressure gauges 47 and 48 is

the pressure of the working oil for driving and rotating the hydraulic motor 43.

By repeating the above-mentioned process constantly, the pressure of the working oil supplied from the hydraulic pump 42 is controlled to be higher, by a maximum pressure of 20kg/cm^2 , than the pressure of the working oil for driving and rotating the hydraulic motor 43.

The current that the oil pressure control circuit 23B feeds to the electromagnetic relief valve 46 via the signal transmission path 36 when the higher one of the hydraulic pressures detected by the pressure gauges 47 and 48 is equal to or higher than a predetermined pressure, is set to be OA (zero A). This current setting causes the electromagnetic relief valve 46 to open, that is, the main relief valve 45 is opened due to the opening of the electromagnetic relief valve 46 to establish an unload state, so that the working oil flows from the main relief valve 45 to the tank 41, and the hydraulic pump 42 receives no load. Accordingly, when the hydraulic drive apparatus is used for the winch, and the hydraulic motor 43 is forcibly driven and rotated by an external load as in the case of winding-down of the winch, the main relief valve 45 may be placed to an unloading state to such an extent that no cavitation occurs in the working oil supplied to the hydraulic motor 43. As a result, there is eliminated the wasteful

consumption of the drive horsepower of the hydraulic pump 42.

Since the required unloading state level is merely to such an extent that no cavitation occurs in the working oil supplied to the hydraulic motor 43, the current that the oil pressure control circuit 23B feeds to the electromagnetic relief valve 46 via the signal transmission path 36 may be set to be a predetermined current other than the current OA.

In the hydraulic drive apparatus of the embodiment, the electro-hydraulic servomechanism carries out such a control that when the electric motor 24 stops, the hydraulic motor 43 also stops.

Accordingly, when the electric motor 24 stands still and the hydraulic motor 43 receives an external load to rotate, the port of the directional control valve 25 is opened and closed to drive and rotate the hydraulic motor 43 to resist the load applied. If the check valve 50 is not provided at the position shown in Fig. 1, the hydraulic motor 43 will run uncontrollably when the hydraulic motor 43 is placed to an unloading state since in this case, the working oil flows in the reverse direction, viz., the working oil flows from the directional control valve 25 through the oil passage 63 to the hydraulic pump 42. If the set pressure of the main relief valve 45 is set to be larger than the load pressure in order to prevent the reverse flow, the drive horsepower of the hydraulic pump 42 is wastefully consumed. In this

connection, if the check valve 50 is provided at the position shown in Fig. 1 as in the embodiment, the main relief valve 45 can be put in an unloaded state without any reverse flow of the working oil, and therefore it is possible to eliminate the wasteful consumption of the drive horsepower of the hydraulic pump 42.

Examples where the hydraulic motor 43 receives an external load while the electric motor 24 stops are: when the hydraulic drive apparatus is applied to the driving machine of a service car, it stops on a sloping road; when the hydraulic drive apparatus is applied to a rotary machine of the service car, the rotating operation stops on a sloping surface; and when the hydraulic drive apparatus is applied to the winch, the winch is stopped.

In hydraulic drive apparatus of the embodiment, a quantity of the working oil that the hydraulic pump 42 supplies is controlled to be 5% larger than the necessary quantity of the working oil for the hydraulic motor 43. Therefore, the flow loss of the hydraulic pump 42 is small.

The control of the quantity of the working oil that the hydraulic pump 42 supplies will be described hereunder.

A quantity of the working oil necessary for driving the hydraulic motor 43 (this quantity will be referred to merely as a necessary quantity) can be obtained from the rotational speed (rotational number) and stroke volume of the hydraulic motor 43.

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The hydraulic motor 43 follows up the electric motor 24 in rotation. Therefore, the rotational speed of the hydraulic motor 43 is equal to the rotational speed of the electric motor 24. In the embodiment, the stroke volume of the hydraulic motor 43 takes
5 a design value. The rotational speed of the electric motor 24 is determined by an operation position signal output from the operation-position signal outputting means 22.

Accordingly, the supplying oil quantity signal output circuit 23C computes a necessary quantity of the hydraulic motor
10 43 by using an operation-position signal output from the operation-position signal outputting means 22 and a known stroke volume of the hydraulic motor 43; generates a supplying oil quantity signal so that the quantity of the working oil supplied from the hydraulic pump 42 is 5% larger than the computed necessary
15 quantity of the hydraulic motor 43; and transmits the generated signal to the pump regulator 51 through a signal transmission path 37. Upon receipt of the supplying oil quantity signal, the pump regulator 51 controls the quantity of the working oil supplied by the hydraulic pump 42 by operating a pump capacity (cc/rev)
20 in accordance with the supplying oil quantity signal.

In this way, the quantity of the working oil that the hydraulic pump 42 supplies is controlled to be 5% higher than the necessary quantity of the hydraulic motor 43.

supplied from the hydraulic pump 42 is controlled to be higher than the pressure of the working oil for driving and rotating the hydraulic motor 43 by a maximum pressure of 20kg/cm². It is evident that the pressure difference is not limited to 20kg/cm² but may be any of other suitable values than it.

In the electro-hydraulic servomechanism mentioned above, if the directional control valve 25 is not provided with a throttle, the hydraulic motor 43 follows up the electric motor 24 in rotation in a quick responsive manner, but it is easy to vibrate. In the hydraulic drive apparatus of the embodiment, the directional control valve 25 includes a large throttle. Therefore, the hydraulic motor 43 smoothly follows up the electric motor 24 in rotation, although its responsive time may be long. In the hydraulic drive apparatus of the embodiment, the throttle of the directional control valve 25 is arranged in the meter-out of the 25A side and in the meter-in of the 25B side. Accordingly, the hydraulic drive apparatus of the embodiment is used in a case where the hydraulic motor 43 constantly receives an external load only in the winding-down direction (indicated by an arrow D in Fig. 1), as in the winch.

<Second Embodiment>

Fig. 2 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a second embodiment of the

present invention.

A basic construction of the hydraulic drive apparatus of the second embodiment is substantially the same as of the first embodiment except that the throttle of the directional control valve 25 is arranged in the meter-in of the 25A side and in the meter-out of the 25B side. The hydraulic drive apparatus is used in a case where the hydraulic motor 43 constantly receives an external load only in the direction of an arrow U in Fig. 2.

<Third Embodiment>

Fig. 3 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a third embodiment of the invention.

A basic construction of the hydraulic drive apparatus of the third embodiment is substantially the same as of each of the first and second embodiments except that the throttle of the directional control valve 25 is arranged in the meter-in and meter-out of the 25A side and in the meter-in and meter-out of the 25B side. The hydraulic drive apparatus is used in a case where the hydraulic motor 43 receives external loads in directions of arrows U and D in Fig. 3.

<Fourth Embodiment>

Fig. 4 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus which is a fourth embodiment of the

present invention.

An arrangement of the hydraulic drive apparatus of the embodiment will be described.

5 The arrangement of the hydraulic drive apparatus of this embodiment is substantially the same as of each of the first to third embodiments except the arrangement to be described hereunder.

10 Reference numeral 143 indicates a hydraulic motor as an additional drive rotary member to be driven and rotated by hydraulic pressure.

15 Reference numeral 120 designates a rotation control means which controls a quantity of the working oil supplied from the hydraulic pump 42 to the hydraulic motor 143, thereby driving and rotating the hydraulic motor 143 as desired. The additional rotation control means 120 is made up of an operation lever 121, an additional operation-position signal outputting means 122, a drive signal output circuit 23A, an electric motor 124, and a directional control valve 125. The operation lever 121 serves as additional operation position inputting means and is able to
20 input a desired operation position. The additional operation-position signal outputting means 122 generates an operation position signal in accordance with an operation position input to the operation lever 121. The drive signal

output circuit 23A serves as additional drive signal outputting means and computes and converts an operation position signal output from the additional operation-position signal outputting means 122 into a drive signal. The electric motor 24 serves as
5 an additional electric motor and is driven and rotated at a speed and a quantity of rotation, both being defined by the drive signal output from the drive signal output circuit 23A. The directional control valve 125 serves as additional working oil control means, and controls a quantity of the working oil supplied from the
10 hydraulic pump 42, and supplies the thus quantity-controlled working oil to the hydraulic motor 143, thereby driving and rotating the hydraulic motor 143 in accordance with rotation of the electric motor 124.

The drive signal output circuit 23A also serves as drive
15 signal outputting means as in the hydraulic drive apparatus of each of the first to third embodiments.

Reference numerals 147 and 148 represent pressure gauges as additional drive oil pressure detecting means. Each of those pressure gauges detects a pressure of the working oil for driving
20 and rotating the hydraulic motor 143, and generates and outputs a drive oil pressure signal depending on the pressure thus detected.

In the embodiment, an oil pressure control circuit 23B as

electrically connected to the oil pressure control circuit 23B through signal transmission paths not shown.

A computer 180 is electrically connected to the drive signal output circuit 23A, oil pressure control circuit 23B, and
5 supplying oil quantity signal output circuit 23C through signal transmission paths not shown.

An operation of the hydraulic drive apparatus of this embodiment will be described.

The operation of this hydraulic drive apparatus is
10 substantially the same as that of each of the hydraulic drive apparatuses of the first to third embodiments.

The additional rotation control means 120 is capable of rotating the hydraulic motor 143 as desired similarly to the rotation control means 20 which drives and rotates the hydraulic
15 motor 43 as desired.

The hydraulic drive apparatus of this embodiment controls the quantity of the working oil supplied from the hydraulic pump 42 so that it is larger than the sum of the necessary quantities of the hydraulic motors 43 and 143 by 5%, in the similar manner
20 as the hydraulic drive apparatus of each of the first to third embodiments does. Therefore, the flow loss of the hydraulic pump 42 is small.

The hydraulic drive apparatus of this embodiment controls

the pressure of the working oil supplied from the hydraulic pump 42 so that it is higher, by a maximum pressure of 20kg/cm^2 , than a higher one of the pressures of the working oils for driving the hydraulic motors 43 and 143, in the similar manner as the hydraulic drive apparatus of each of the first to third embodiments does. Therefore, there is eliminated the wasteful consumption of the drive horsepower of the hydraulic pump 42.

In the hydraulic drive apparatus of this embodiment, the computer 180 has various functions. Examples of the functions are: it outputs a signal to the drive signal output circuit 23A by way of a signal transmission path (not shown) to set rotational speeds of the electric motors 24 and 124; it outputs a signal to the oil pressure control circuit 23B by way of a signal transmission path (not shown) to set a set pressure of the electromagnetic relief valve 46; and it outputs a signal to the supplying oil quantity signal output circuit 23C via a signal transmission path to set a quantity of working oil discharged from the hydraulic pump 42.

In this embodiment, the hydraulic motor 43 is driven and rotated in response to the operation position signal input from the operation lever 21, and the hydraulic motor 143 is driven and rotated in response to the operation position input from the operation lever 121. Alternatively, those hydraulic motors 43

and 143 may be driven and rotated in response to an operation position input from one operation lever.

While in this embodiment, the hydraulic drive apparatus includes two electro-hydraulic servovalves, it may include three
5 or more number of electro-hydraulic servovalves.

<5th Embodiment>

Fig. 6 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100, which is a fifth embodiment of the present invention.

10 An arrangement of the hydraulic drive apparatus 100 of the embodiment will be described.

In Fig. 6, the hydraulic drive apparatus 100 includes a hydraulic pump 102 for supplying working oil from a tank 101 through an oil passage 111 to an oil passage 112.

15 The hydraulic drive apparatus 100 includes a first hydraulic motor 201 and a second hydraulic motor 301. The first hydraulic motor 201 receives working oil from the hydraulic pump 102 through one of oil passages 113 and 114 and the oil passage 112, and is driven and rotated by the supplied working oil. The
20 second hydraulic motor 301 receives working oil from the hydraulic pump 102 through the oil passages 112, 118, 119 and 120 and an oil passage 122 or 123, and is driven and rotated by the supplied working oil.

The hydraulic drive apparatus 100 further includes a first operation unit 200 which is made up of a first operation lever 210 as first operation position input means which receives an operation position, and generates and outputs an operation position signal indicative of the input operation position, a drive signal output circuit 220A as drive signal outputting means which receives the operation position signal from the first operation lever 210 by way of a signal transmission path 16, computes the operation position signal into a drive signal, and outputs the drive signal, an electric motor 230 which receives a drive signal through a signal transmission path 162 from the drive signal output circuit 220A, and is driven and rotated at a rotational speed defined by the drive signal received, and a first control valve 250 which allows the working oil supplied from the hydraulic pump 102 to the first hydraulic motor 201 to flow therethrough, adjusts a quantity of the working oil flowing therethrough in accordance with the rotational speeds of the electric motor 230 and the first hydraulic motor 201, and thereby adjusts a quantity of the working oil supplied from the hydraulic pump 102 to the first hydraulic motor 201, whereby the first hydraulic motor 201 is driven and rotated in accordance with the operation position input to the first operation lever 210.

In the hydraulic drive apparatus, a drive rotation of the

first hydraulic motor 201 is reduced in speed by a speed reduction mechanism 202 and thereafter is transmitted to a load 203. As described above, the first control valve 250 is constructed such that it allows the working oil supplied from the hydraulic pump 102 to the first hydraulic motor 201 to flow therethrough, adjusts a quantity of the working oil flowing therethrough in accordance with the rotational speeds of the electric motor 230 and the first hydraulic motor 201, and thereby adjusts a quantity of the working oil supplied from the hydraulic pump 102 to the first hydraulic motor 201. To be more specific, the first control valve 250 is coupled to the rotary shaft of the electric motor 230 and to the rotary shaft of the first hydraulic motor 201 by means of screws.

When a rotational speed difference is produced between the electric motor 230 and the first hydraulic motor 201, the first control valve adjusts a quantity of the working oil flowing therethrough, viz., a quantity of the working oil supplied from the hydraulic pump 102 to the first hydraulic motor 201, so that the rotational speed of the electric motor 230 is equal to that of the first hydraulic motor 201. In this state, the first hydraulic motor 201 is driven and rotated. The working oil having rotated the first hydraulic motor 201 passes through the other of the oil passages 113 and 114. And it passes through the first control valve 250 again and further through an oil passage 115,

and returns to the tank 101.

The first control valve 250 constitutes an electro-hydraulic servovalve.

The hydraulic drive apparatus 100 includes a second operation unit 300, which is made up of a second operation lever 310 as second operation position inputting means to which an operation position is input, and a second control valve 350 which allows the working oil supplied from the hydraulic pump 102 to the second hydraulic motor 301 to flow therethrough, adjusts a quantity of the working oil flowing therethrough in accordance with an operation position input to the second operation lever 310, whereby the second hydraulic motor 301 is driven and rotated in accordance with an operation position input to the second operation lever 310.

The oil passages 120 and 121 intercommunicate with each other through a check valve 170. A drive rotation of the second hydraulic motor 301 is reduced in speed by a speed reduction mechanism 302, and transmitted to a load 303. The working oil having rotated the second hydraulic motor 301 passes through the other of the oil passages 122 and 123, and again through the second control valve 350. Further, it passes through an oil passage 124 and returns to the tank 101. Of the working oil flowing through the oil passage 119, working oil other than the working oil

supplied to the second hydraulic motor 301 is supplied again to the tank 101 via the second control valve 350 and an oil passage 125.

5 The second control valve 350 constitutes a general purpose valve.

10 The hydraulic drive apparatus 100 includes a pressure sensor 131 as supplying oil detect means which detects a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250, and generates a supplying-oil pressure signal dependent on the pressure, and pressure sensors 132 and 133 as drive oil pressure detecting means which detects a pressure of the working oil for driving and rotates the first hydraulic motor 201 and generates and outputs a drive oil pressure signal that is dependent on the pressure. The pressure sensors 131, 132 and 133 are arranged so as to detect pressures of the working oil flowing through the oil passages 112, 113 and 114.

15 The hydraulic drive apparatus 100 also includes a pressure control valve 140 as first working oil adjusting means, a pressure control valve 150 as second working oil pressure adjusting means and a pressure adjust signal output circuit 220B as pressure adjust signal outputting means. The pressure control valve 140 receives working oil from the hydraulic pump 102 via the oil passages 112 and 116, allows the supplied working oil to flow therethrough,

and adjusts a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to be below a set pressure. The pressure control valve 150 allows the working oil supplied from the hydraulic pump 102 to the second control valve 350 to flow therethrough, and adjusts a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to be below a set pressure. The pressure adjust signal output circuit 220B receives an operation position signal from the first operation lever 210 via the signal transmission path 161, a supplying-oil pressure signal from the pressure sensor 31 via a signal transmission path, and a drive oil pressure signal from each of the pressure sensors 132 and 133 via signal transmission paths (not shown). The pressure adjust signal output circuit 220B judges, by the input operation position signal, whether the first hydraulic motor 201 drives and rotates the first hydraulic motor 201 or stops the rotation of the first hydraulic motor 201. When the first operation unit 200 drives and rotates the first hydraulic motor 201, the pressure adjust signal output circuit computes a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by use of the input supplying-oil pressure signal and the drive oil pressure signal. The pressure adjust signal output circuit generates a pressure adjust signal which causes the pressure control valve

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150 to adjust a set pressure of the pressure control valve 150 so that the set pressure is higher, by a predetermined pressure, than a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201. In the embodiment, the
5 predetermined pressure is 20 Kg/cm². When the first operation unit 200 stops the rotation of the first hydraulic motor 201, the pressure adjust signal output circuit generates a pressure adjust signal which causes the pressure control valve 150 to adjust a set pressure thereof to such a pressure (0 Kg/cm² in the embodiment)
10 at which the pressure control valve 150 allows the working oil to freely flow. Then, the pressure adjust signal output circuit outputs the generated pressure adjust signal through a signal transmission path 163 to the pressure control valve 150.

The working oil having passed through the pressure control valve 140 is returned to the tank 101, through an oil passage 117.
15

The pressure control valve 150 includes a main relief valve 151 and an electromagnetic relief valve 152. The main relief valve 151 adjusts a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to a set pressure
20 or smaller, by flowing the working oil supplied from the hydraulic pump 102. The electromagnetic relief valve 152 adjusts a set pressure of the main relief valve 151 by adjusting a set pressure thereof in accordance with a pressure adjust signal as input

thereto through the signal transmission path 163.

As shown in Fig. 6, the first control valve 250, pressure control valve 140 and pressure control valve 150 are arranged so that the pressures of the working oil supplied thereto are equal to one another.

The hydraulic drive apparatus 100 includes a pump regulator 180, a pressure sensor 134, and a supplying-oil adjust signal output circuit 220C. The pump regulator 180 as supplying oil quantity adjusting means adjusts a quantity of the working oil that the hydraulic pump 102 supplies. The pressure sensor 34 as operation position detecting means detects an operation position input to the second operation lever 310, and generates and outputs an operation position detect signal defined by the operation position. The supplying-oil adjust signal output circuit 220C as supplying oil quantity adjusting signal outputting means receives an operation position signal from the first operation lever 210 by way of the signal transmission path 161, and an operation position detect signal from the pressure sensor 134 by way of a signal transmission path (not shown). The supplying-oil adjust signal output circuit judges, by the input operation position detect signal, whether the second operation unit 300 drives and rotates the second hydraulic motor 301 or stops the rotation of the second hydraulic motor 301. When the second

operation unit 300 drives and rotates the second hydraulic motor 301, the supplying-oil adjust signal output circuit generates a supplying-oil adjust signal which causes the pump regulator 180 to adjust a quantity of the working oil that the hydraulic pump 102 supplies to a predetermined quantity, e.g., a maximum oil quantify of the hydraulic pump 102 in the embodiment. When the second operation unit 300 stops the rotation of the second hydraulic motor 301, the supplying-oil adjust signal output circuit computes a quantity of the working oil necessary for driving and rotating the first hydraulic motor 201 in accordance with an operation position signal input thereto through the signal transmission path 161. The supplying-oil adjust signal output circuit generates a supplying-oil adjust signal which causes the pump regulator 180 to adjust a quantity of the working oil that the hydraulic pump 102 supplies to be larger than that of the working oil necessary for driving and rotating the first hydraulic motor 201 by a predetermined quantity (5% in the embodiment).

Then, the supplying-oil adjust signal output circuit outputs the generated oil quantity adjust signal through the signal transmission path 164 to the pump regulator 180.

The drive signal output circuit 220A, pressure adjust signal output circuit 220B or supplying-oil adjust signal output circuit 220C are accommodated in a control unit 220.

An operation of the hydraulic drive apparatus 100 thus constructed will be described.

A case (referred to as a first case) where the first operation unit 200 drives and rotates the first hydraulic motor 201 and the second operation unit 300 stops the rotation of the second hydraulic motor 301 will first be described.

The hydraulic pump 102 feeds working oil from the tank 101 to the oil passage 112 via the oil passage 111.

In the first case, the first operation unit 200 drives and rotates the first hydraulic motor 201 in accordance with an operation position input to the first operation lever 210. Description to follow is an operation of the hydraulic pump when the first operation unit 200 drives and rotates the first hydraulic motor 201 in accordance with an operation position input to the first operation lever 210.

An operation position is input to the first operation lever 210. Upon receipt of the operation position, the first operation lever 210 generates an operation position signal that is dependent on the input operation position. The generated operation position signal is output from the first operation lever 210 to the signal transmission path 161, and input to the drive signal output circuit 220A via the signal transmission path 161.

The drive signal output circuit 220A computes the operation

passage 114, and then through the first control valve 250, and returned to the tank 101 via the oil passage 115.

In the first case, the second operation unit 300 stops the rotation of the second hydraulic motor 301. Therefore, the second control valve 350 is at a neutral position. After passing the pressure control valve 150, the working oil goes again to the tank 101 by way of the oil passages 119, second control valve 350 and oil passage 125.

In the first case, a quantity of the working oil that the hydraulic pump 102 supplies is set to be 5% larger than that of the working oil for driving and rotating the first hydraulic motor 201. An operation of the hydraulic drive apparatus to set a quantity of the working oil supplied by the hydraulic pump 102 to be 5% larger than a quantity of the working oil for driving and rotating the first hydraulic motor 201, will be described.

The operation position signal is input to the supplying-oil adjust signal output circuit 220C via the signal transmission path 161.

A supplying-oil pressure signal output from the pressure sensor 131 and an operation position detect signal output from the pressure sensor 134 are input to the supplying-oil adjust signal output circuit 220C via a signal transmission path, not shown.

supplying-oil adjust signal output circuit 220C is output to a signal transmission path 164, from the supplying-oil adjust signal output circuit 220C, and is input to the pump regulator 180 by way of the signal transmission path 164. The pump regulator 180 having received the supplying-oil adjust signal adjusts a quantity of the working oil that the hydraulic pump 102 supplies so that a quantity of the working oil that the hydraulic pump 102 is 5% larger than the working oil necessary for driving and rotating the first hydraulic motor 201.

10 In this way, a quantity of the working oil that the hydraulic pump 102 supplies is 5% larger than that of the working oil necessary for driving and rotating the first hydraulic motor 201.

15 In the first case, the supplying-oil pressure signal that is input to the supplying-oil adjust signal output circuit 220C is no used by the supplying-oil adjust signal output circuit 220C in order to generate a supplying-oil adjust signal.

20 In the first case, a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is set to be higher than that of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower.

Description will be given hereunder about an operation of the hydraulic drive apparatus to set the pressure of the working oil supplied from the hydraulic pump 102 to the first control valve

250 to be higher than that of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower.

An operation position signal is input from the first operation lever 210 to the pressure adjust signal output circuit 220B, from the signal transmission path 161.

The pressure sensor 131 detects a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250, and generates a supplying-oil pressure signal defined by the detect pressure. The generated supplying-oil pressure signal is output from the pressure sensor 131 to the signal transmission path, and through the signal transmission path to pressure adjust signal output circuit 220B.

Each of the pressure sensors 132 and 133 detects a pressure of the working oil for driving and rotating the first hydraulic motor 201, and generates a drive oil pressure signal defined by the detected pressure. The generated drive oil pressure signal is output to the signal transmission path (not shown) from each of those sensors 132 and 133, and passes through the signal transmission path to the pressure adjust signal output circuit 220B.

The pressure adjust signal output circuit 220B judges, by the input operation position signal, that the first operation unit 200 drives and rotates the first hydraulic motor 201, and computes

a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by use of the input drive oil pressure signal. In the embodiment, the pressure adjust signal output circuit 220B receives the drive oil pressure signals from the pressure sensors 132 and 133. The pressure adjust signal output circuit 220B judges that the pressure, which is the larger of the pressures obtained from the two drive oil pressure signals, is the pressure of the working oil for driving and rotating the first hydraulic motor 201. The pressure adjust signal output circuit 220B obtains a pressure of the working oil, which is supplied from the hydraulic pump 102 to the first control valve 250, from the supplying-oil pressure signal. The pressure adjust signal output circuit 220B generates a pressure adjust signal for adjusting a set pressure of the pressure control valve 150 so that a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is higher than a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower.

The pressure adjust signal is generated by the pressure adjust signal output circuit 220B and output to the signal transmission path 163, and to the pressure control valve 150 via the signal transmission path 163. That is, the pressure adjust signal is input to the electromagnetic relief valve 152. The

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In the second case, the second operation unit 300 drives and rotates the second hydraulic motor 301 in accordance with the operation position input to the second operation lever 310.

Description will be given about an operation of the hydraulic drive apparatus when the second operation unit 300 drives and rotates the second hydraulic motor 301 in accordance with an operation position input to the second operation lever 310.

An operation position is input to the second operation lever 310. When the operation position is input to the second operation lever 310, working oil flows through the operation oil passage 311 or 312 in accordance with the operation position input to the second operation lever 310. Then, the second control valve 350 adjusts a quantity of the working oil that comes in through the oil passages 121, in accordance with the operation oil flowing through the operation oil passage 311 or 312. The working oil having passed through the second control valve 350 passes through one of the oil passages 122 and 123, and drives and rotates the second hydraulic motor 301. When the second hydraulic motor 301 is driven to rotate, a rotation of the second hydraulic motor 301 is reduced in speed and transmitted to the load 303.

In this way, the second operation unit 300 drives and rotates the second hydraulic motor 301 in accordance with the operation

position input to the second operation lever 310.

After driving and rotating the second hydraulic motor 301, the working oil passes the other of the oil passages 122 and 123 and through the second control valve 350, and returns to the tank 101 by way of the oil passage 124.

In the second case, a pressure of the working oil supplied from the hydraulic pump 102 to the second control valve 350 is set to be below a set pressure of the pressure control valve 140.

An operation of the hydraulic drive apparatus to set a pressure of the working oil supplied from the hydraulic pump 102 to the second control valve 350 below a set pressure of the pressure control valve 140, will be described.

As described in the first case, the operation position signal, supplying-oil pressure signal drive oil pressure signal are input to the pressure adjust signal output circuit 220B.

The pressure adjust signal output circuit 220B judges from the input operation position signal that the first operation unit 200 stops the rotation of the first hydraulic motor 201. The pressure adjust signal output circuit 220B generates a pressure adjust signal which sets a set pressure of the pressure control valve 150 at 0 kg/cm², and inputs the generated pressure adjust signal to the pressure control valve 150 by way of the signal transmission path 163.

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Accordingly, a pressure of the working oil supplied from hydraulic pump 102 to the first control valve 250, viz., a pressure of the working oil supplied from the hydraulic pump 102 to the second control valve 350, is a set pressure of the pressure control valve 140 or lower.

In this way, a pressure of the working oil supplied from the hydraulic pump 102 to the second control valve 350 is a set pressure of the pressure control valve 140 or lower.

In the second case, the supplying-oil pressure signal and the drive oil pressure signal that are input to the pressure adjust signal output circuit 220B are not used by the pressure adjust signal output circuit 220B for generating the pressure adjust signal.

The working oil having flowed through the pressure control valve 140 is supplied to the tank 101 via the oil passage 117.

In the second case, a quantity of the working oil that the hydraulic pump 102 supplies is set to be a maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil. An operation of the hydraulic drive apparatus to set a quantity of the working oil that the hydraulic pump 102 supplies to be a maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil, will be described.

As described in the first case, the operation position

signal is input through the signal transmission path 161 to the supplying-oil adjust signal output circuit 220C, and the supplying-oil pressure signal and the operation position detect signal are input to the same by way of a signal transmission path, not shown.

The supplying-oil adjust signal output circuit 220C judges, by the input operation position detect signal, that the second operation unit 300 drives and rotates the second hydraulic motor 301, and computes the maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil in accordance with the input supplying-oil pressure signal. The supplying-oil adjust signal output circuit 220C computes the maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil, by use of a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250, the pressure being presented by the supplying-oil pressure signal, and the limited horsepower of the engine for driving the hydraulic pump 102. Further, the supplying-oil adjust signal output circuit 220C generates a supplying-oil adjust signal, which causes the pump regulator 180 to adjust a quantity of the working oil that the hydraulic pump 102 supplies so that a quantity of the working oil that the hydraulic pump 102 supplies is equal to the maximum oil quantity at which the hydraulic pump 102 is capable

of supplying the working oil.

The supplying-oil adjust signal generated by the supplying-oil adjust signal output circuit 220C is output from the supplying-oil adjust signal output circuit 220C to the signal transmission path 164, and input to the pump regulator 180 via the signal transmission path 164. The pump regulator 180, which receives the supplying-oil adjust signal, adjusts a quantity of the working oil that the hydraulic pump 102 supplies so that a quantity of the working oil that the hydraulic pump 102 supplies is equal to the maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil.

In this way, the quantity of the working oil that the hydraulic pump 102 supplies is set to be the maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil.

In the second case, the operation position signal input to the supplying-oil adjust signal output circuit 220C is not used by the supplying-oil adjust signal output circuit 220C to generate the supplying-oil adjust signal.

As described above, in the second case, the pressure of the working oil supplied from the hydraulic pump 102 to the second control valve 350 is below the set pressure of the pressure control valve 140. The quantity of the working oil that the hydraulic

pump 102 is set at the maximum oil quantity at which the hydraulic pump 102 can supply the working oil.

A case (referred to as a third case) where the first operation unit 200 drives and rotates the first hydraulic motor 201, and
5 the second operation unit 300 drives and rotates the second hydraulic motor 301, will be described.

The hydraulic pump 102 supplies the working oil from the tank 101 through the oil passage 111 to the oil passage 112.

10 In the third case, as in the first case, the first operation unit 200 drives and rotates the first hydraulic motor 201 in accordance with the operation position input to the first operation lever 210.

15 In the third case, as in the first case, the second operation unit 300 drives and rotates the second operation lever 310 in accordance with the operation position input to the second operation lever 310.

20 In the third case, when a pressure of the working oil in the oil passages 119 is lower than the set pressure of the pressure control valve 150, a pressure of the working oil supplied through the oil passage 112 to the first control valve 250 is higher than a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm^2 or lower. When a pressure of the working oil in the oil passages 119 is higher than

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the set pressure of the pressure control valve 150, a pressure of the working oil supplied through the oil passage 112 to the first control valve 250 is substantially equal to a pressure of the working oil supplied through the oil passages 121 to the second control valve 350, and equal to a set pressure of the pressure control valve 140 or lower. This will be described in detail.

In the third case, the first operation unit 200 drives and rotates the first hydraulic motor 201. Therefore, as in the first case, a set pressure of the pressure control valve 150 is set to be higher than a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm^2 , by the pressure adjust signal output circuit 220B. Specifically, when a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is higher than a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm^2 , the pressure adjust signal output circuit 220B causes the pressure control valve 150 to open the passage, and hence flows the working oil from the oil passage 118 to the oil passage 119 and lowers the pressure of the working oil.

Accordingly, when a pressure of the working oil in the oil passages 119 is lower than a set pressure of the pressure control valve 150, a pressure of the working oil supplied through the oil passage 112 to the first control valve 250 is lower than the set

pressure of the pressure control valve 150, viz., lower than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower. When the pressure of the working oil in the oil passages 119 is higher than the set pressure of the pressure control valve 150, the pressure of the working oil in the oil passage 118 is substantially equal to the pressure of the working oil in the oil passages 119.

Therefore, a pressure of the working oil supplied through the oil passage 112 to the first control valve 250 is substantially equal to the pressure of the working oil, and equal to the set pressure of the pressure control valve 140 or lower.

In the third case, the second operation unit 300 drives and rotates the second hydraulic motor 301. Accordingly, as in the second case, a quantity of the working oil is set at the maximum oil quantity at which the hydraulic pump 102 can supply the working oil, by the supplying-oil adjust signal output circuit 220C.

As described above, in the third case, when the pressure of the working oil in the oil passages 119 is lower than the set pressure of the pressure control valve 150, the pressure of the working oil supplied through the oil passage 112 to the first control valve 250 is higher than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower. When the pressure of the working oil in

the oil passages 119 is higher than the set pressure of the pressure control valve 150, the pressure of the working oil supplied through the oil passage 112 to the first control valve 250 is substantially equal to the pressure of the working oil supplied through the oil passages 121 to the second control valve 350, and equal to the set pressure of the pressure control valve 140 or lower. A quantity of the working oil that the hydraulic pump 102 supplies is set at the maximum oil quantity at which the hydraulic pump 102 can supply the working oil.

In the embodiment, in the first and third cases, the set pressure of the pressure control valve 150 is higher than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by $20\text{kg}/\text{cm}^2$. In the embodiment, the predetermined pressure may be selected within a range of any other suitable values than $20\text{kg}/\text{cm}^2$ if the range does not give rise to the wasting of the drive horsepower of the hydraulic pump 102. In the second case, the set pressure of the pressure control valve 150 is set at $0\text{kg}/\text{cm}^2$, but it may be selected within a range of other pressure values than $0\text{kg}/\text{cm}^2$ if the range allows the working oil in the oil passages 118 to substantially and freely flow to the oil passages 119.

In the embodiment, in the first case, a quantity of the working oil that the hydraulic pump 102 supplies is 5% larger than

Fig. 7 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100, which is a sixth embodiment of the present invention.

In the fifth embodiment, as recalled, the pressure control valve 150 of the hydraulic drive apparatus 100 is made up of the main relief valve 151 and the electromagnetic relief valve 152.

In the hydraulic drive apparatus 100 of the sixth embodiment, the pressure control valve 150 consists of only an electromagnetic relief valve 153. The remaining construction of the sixth embodiment is substantially the same as of the hydraulic drive apparatus 100 of the fifth embodiment.

Accordingly, an operation of the hydraulic drive apparatus 100 of the present embodiment is similar to that of the hydraulic drive apparatus 100 of the fifth embodiment.

<Seventh Embodiment>

Fig. 8 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100 which is a seventh embodiment of the present invention.

An arrangement of the hydraulic drive apparatus 100 of the present embodiment will first be described.

The arrangement of the hydraulic drive apparatus 100 of the present embodiment is substantially the same as of the hydraulic drive apparatus 100 of the fifth embodiment except its arrangement

to be described hereunder.

The hydraulic drive apparatus 100 of the embodiment uniquely includes an additional hydraulic motor 401 between the oil passage 125 and the tank 101. The additional hydraulic motor 401 is driven and rotated by working oil supplied thereto from the hydraulic pump 102 through a route of the oil passages 112, 118 and 119, the second control valve 350, and the oil passages 125, 181 and 182, and an oil passage 183 or 184.

The hydraulic drive apparatus 100 includes an additional operation unit 400 which is made up of an additional operation lever 410 as additional operation position inputting means to which an operation position is input, and an additional control valve 450 which allows the working oil supplied from the hydraulic pump 102 to the additional hydraulic motor 401 to flow therethrough, adjusts a quantity of the working oil flowing therethrough in accordance with an operation position input by the additional operation lever 410, and adjusts a quantity of the working oil supplied from the hydraulic pump 102 to the additional hydraulic motor 401, whereby the additional hydraulic motor 401 is driven in accordance with the operation position input to the additional operation lever 410.

The oil passages 181 and 182 intercommunicate with each other through a check valve 171. A rotation of the additional hydraulic

motor 401 is reduced in speed by a speed reduction means 402 and transmitted to a load 403. The working oil have driven and rotated the additional hydraulic motor 401 passes through the additional hydraulic motor 401, passes again through the oil passage 183 or 184, and returns to the tank 101 via the oil passage 185. Of the working oil flowing through the oil passage 125, the working oil other than that supplied to the additional hydraulic motor 401 flows through the additional control valve 450 and an oil passage 186, and returns to the tank 101.

10 The additional control valve 450 is a general purpose valve.

The additional control valve 450 is arranged such that a quantity of the working oil flowing therethrough is adjusted in accordance with the operation position input to the additional operation lever 410. To be more specific, the additional operation lever 410 supplies a quantity of the working oil, which depends on the input operation position. The additional control valve 450 receives the operation position from the additional operation lever 410 through operation oil passage 411 or 412, and adjusts the working oil flowing therethrough in accordance with a quantity of the operation oil supplied.

A pressure sensor 135 as operation position detecting means detects an operation position input to the additional operation lever 410. Specifically, the pressure sensor 135 detects a

pressure of the operation oil, which is the higher of the operation oils flowing through operation oil passages 411 and 412, and detects a pressure of the operation oil supplied from the additional operation lever 410 to the additional control valve 450 by the former pressure detection.

As recalled, in the fifth embodiment, the supplying-oil adjust signal output circuit 220C judges by the operation position detect signal input thereto, that the second operation unit 300 stops the rotation of the second hydraulic motor 301. In this connection, the present embodiment, the supplying-oil adjust signal output circuit 220C judges, by each of the operation position detect signal input thereto, that the second operation unit 300 and the additional operation unit 400 stop the second hydraulic motor 301 and the additional hydraulic motor 401, respectively. Also in the fifth embodiment, the supplying-oil adjust signal output circuit 220C judges, by the operation position detect signal input thereto, that the second operation unit 300 stops the rotation of the second hydraulic motor 301.

In this connection, in the embodiment, the supplying-oil adjust signal output circuit 220C judges, by each position detect signal input thereto, that either of the second operation unit 300 and the additional operation unit 400 drives and rotates either of the second hydraulic motor 301 and the additional hydraulic motor

401.

Accordingly, the operation of the hydraulic drive apparatus 100 of the present embodiment is substantially the same as of the hydraulic drive apparatus 100 of the fifth embodiment except that the additional hydraulic motor 401 may be operated.

In the hydraulic drive apparatus 100 of the present embodiment, it is impossible to simultaneously operate the second hydraulic motor 301 and the additional hydraulic motor 401.

<Eighth Embodiment>

Fig. 9 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100 which is an eighth embodiment of the present invention.

An arrangement of the hydraulic drive apparatus 100 of this embodiment will be described.

The arrangement of the hydraulic drive apparatus 100 of this embodiment is substantially the same as of the hydraulic drive apparatus 100 of the seventh embodiment except that while the oil passage 181 in the hydraulic drive apparatus 100 of the seventh embodiment communicates with the oil passage 125, the oil passage 181 in the hydraulic drive apparatus 100 of this embodiment communicates with the oil passages 119.

An operation of the hydraulic drive apparatus 100 of the embodiment will be described.

The hydraulic drive apparatus 100 of the fifth embodiment includes the pressure adjust signal output circuit 220B and the supplying-oil adjust signal output circuit 220C. The hydraulic drive apparatus 100 of this embodiment includes an oil quantity adjust signal output circuit 220D as oil quantity adjust signal outputting means. The oil quantity adjust signal output circuit 220D receives an operation position signal from the first operation lever 210, and generates a working oil quantity adjust signal for causing the flow control valve 190 to adjust a quantity of the working oil flowing therethrough in accordance with the operation position signal, and further generates a supplying oil quantity adjust signal for causing the pump regulator 180 to adjust a quantity of the working oil that the hydraulic pump 102 supplies. The oil quantity adjust signal output circuit 220D outputs the generated working oil quantity adjust signal to the flow control valve 190, and the supplying oil adjust signal to the pump regulator 180. In the hydraulic drive apparatus 100 of the embodiment, the drive signal output circuit 220A and the oil quantity adjust signal output circuit 220D are contained in the control unit 220.

The pressure control valve 140 forms working oil pressure adjusting means, which receives the working oil from the hydraulic pump 102, allows the working oil to flow therethrough, and adjusts

a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to be below the set pressure.

An operation of the hydraulic drive apparatus 100 of the present invention will be described.

5 A case (referred to as a first case) where the first operation unit 200 drives and rotates the first hydraulic motor 201, and the second operation unit 300 stops the rotation of the second hydraulic motor 301, will first be described.

10 In the first case, as in the fifth embodiment, the first hydraulic motor 201 is driven and rotated, by the first operation unit 200, and the second hydraulic motor 301 is stopped in rotation by the second operation unit 300.

15 In the first case, a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is controlled, by the pressure control valve 140, to be the set pressure of the pressure control valve 140 or lower. The working oil having passed through the pressure control valve 140 is supplied again to the tank 101 via the oil passage 117.

20 In the first case, a quantity of the working oil that the hydraulic pump 102 supplies is set to be 5% larger than a quantity of the working oil necessary for driving and rotating the first hydraulic motor 201. A quantity of the working oil flowing through the flow control valve 190 is set to be 5% of a quantity

of the working oil necessary for driving and rotating the first hydraulic motor 201. Description will be given hereunder about an operation of the hydraulic drive apparatus to set a quantity of the working oil that the hydraulic pump 102 supplies to be 5% larger than a quantity of the working oil necessary for driving and rotating the first hydraulic motor 201, and to set a quantity of the working oil flowing through the flow control valve 190 to be 5% of a quantity of the working oil necessary for driving and rotating the first hydraulic motor 201.

10 The operation position signal is input from the first operation lever 210 to the oil quantity adjust signal output circuit 220D via the signal transmission path 161.

15 The supplying-oil pressure signal output from the pressure sensor 131 and the operation position detect signal output from the pressure sensor 134 are input to the oil quantity adjust signal output circuit 220D by way of a signal transmission path, not shown.

20 The oil quantity adjust signal output circuit 220D judges, by the operation position detect signal input thereto, that the second operation unit 300 stops the rotation of the second hydraulic motor 301. The oil quantity adjust signal output circuit, like the supplying-oil adjust signal output circuit 220C in the fifth embodiment, computes a quantity of the working oil

necessary for driving and rotating the first hydraulic motor 201 by use of the operation position signal input thereto. The oil quantity adjust signal output circuit 220D generates a supplying-oil adjust signal which causes the pump regulator 180 to adjust a quantity of the working oil that the hydraulic pump 102 supplies so that a quantity of the working oil flowing through the flow control valve 190 is 5% larger than the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201. The oil quantity adjust signal output circuit further generates a working oil quantity adjust signal which causes a quantity of the working oil flowing through the flow control valve 190 so that a quantity of the working oil flowing through the flow control valve 190 is 5% of the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201.

The supplying-oil adjust signal generated is output from the oil quantity adjust signal output circuit 220D to the signal transmission path 164, and then to the pump regulator 180. Upon receipt of the supplying-oil adjust signal, the pump regulator 180 adjusts a quantity of the working oil supplied from the hydraulic pump 102 so that the quantity of the working oil that the hydraulic pump 102 supplies is 5% larger than the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201.

The working oil quantity adjust signal generated is output from the oil quantity adjust signal output circuit 220D to the signal transmission path 163 and then to the flow control valve 190. Upon receipt of the working oil quantity adjust signal, the flow control valve 190 adjusts a quantity of the working oil flowing through the valve is 5% of the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201.

In this way, the quantity of the working oil that the hydraulic pump 102 supplies is set to be 5% larger than the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201. The quantity of the working oil flowing through the flow control valve 190 is set to be 5% of the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201.

In the first case, the supplying-oil pressure signal input to the oil quantity adjust signal output circuit 220D is not used by the oil quantity adjust signal output circuit 220D to generate the supplying-oil adjust signal and the working oil quantity adjust signal.

As described above, in the first case, the quantity of the working oil that the hydraulic pump 102 supplies is set to be 5% larger than the quantity of the working oil necessary for driving

and rotating the first hydraulic motor 201. The quantity of the working oil flowing through the flow control valve 190 is set to be 5% of the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201. Therefore, a
5 sufficient amount of the working oil for driving the first hydraulic motor 201 is fed to the first hydraulic motor 201.

Description will be given hereunder about a case (referred to as a second case) where the first operation unit 200 stops the rotation of the first hydraulic motor 201, and the second operation
10 unit 300 drives and rotates the second hydraulic motor 301.

In the second case, as in the fifth embodiment, the first hydraulic motor 201 is stopped in rotation by the first operation unit 200, and the second hydraulic motor 301 is driven and rotated by the second operation unit 300.

15 Also in the second case, as in the first case, a pressure of the working oil fed from the hydraulic pump 102 to the first control valve 250 is controlled, by the pressure control valve 140, to be the set pressure of the pressure control valve 140 or lower.

20 In the second case, a quantity of the working oil that the hydraulic pump 102 is set to be the maximum oil quantity at which the hydraulic pump 102 is capable of supplying the working oil, and the flow control valve 190 is set to allow the working oil

to freely flow therethrough.

Description will next be given hereunder about an operation of the hydraulic drive apparatus 100 to set the quantity of the working oil supplied by the hydraulic pump 102 at the maximum oil quantity at which the hydraulic pump 102 can supply, and to set the flow control valve 190 so that it allows the working oil to freely flow therethrough.

The oil quantity adjust signal output circuit 220D receives the operation position signal through the signal transmission path 161, and the supplying-oil pressure signal and operation position detect signal through a signal transmission path, not shown.

The oil quantity adjust signal output circuit 220D judges, by the operation position signal input thereto, that the first operation unit 200 stops the rotation of the first hydraulic motor 201. The oil quantity adjust signal output circuit, as the supplying-oil adjust signal output circuit 220C of the fifth embodiment so does, computes the maximum oil quantity at which the hydraulic pump 102 can supply the working oil by use of the supplying-oil pressure signal. And the oil quantity adjust signal output circuit 220D computes a supplying-oil adjust signal which causes the pump regulator 180 to adjust a quantity of the working oil that the hydraulic pump 102 supplies so that a quantity

control valve 190 so that the working oil flowing from the oil passages 118 through the flow control valve 190 to the oil passages 119 may freely flow into the flow control valve 190.

In this way, the quantity of the working oil that the hydraulic pump 102 supplies is set to be the maximum oil quantity that the hydraulic pump 102 can supply the working oil, and the flow control valve 190 is set to allow the working oil to freely flow therethrough.

In the second case, the operation position signal input to the oil quantity adjust signal output circuit 220D is not used by the oil quantity adjust signal output circuit 220D to generate supplying-oil adjust signal.

As described above, in the second case, a quantity of the working oil that the hydraulic pump 102 supplies is set to be equal to the maximum oil quantity at which the hydraulic pump 102 can supply the working oil, and the flow control valve 190 is set to allow the working oil to freely flow therethrough. Accordingly, the maximum oil quantity at which the hydraulic pump 102 can supply the working oil is supplied to the second hydraulic motor 301.

Description will now be given hereunder about a case (referred to as a third case) where the first operation unit 200 drives and rotates the first hydraulic motor 201 and the second operation unit 300 drives and rotates the second hydraulic motor

oil is supplied to the second hydraulic motor 301 at the maximum oil quantity at which the hydraulic pump 102 can supply the working oil.

In the present embodiment, in the first case, the quantity of the working oil that the hydraulic pump 102 supplies is 5% larger than that of the working oil necessary for driving and rotating the first hydraulic motor 201, and the quantity of the working oil that flows through the flow control valve 190 is 5% of the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201. The predetermined quantity of the working oil may take any value other than 5% if it falls within a range where the flow loss is substantially small. In the second and third cases, the quantity of the working oil that the hydraulic pump 102 supplies is equal to the maximum oil quantity of the working oil that the hydraulic pump 102 can supply. Quantity values near the maximum oil quantity suffices for the required quantity of the working oil that the hydraulic pump 102 supplies.

In the present embodiment, the additional hydraulic motor and the additional operation unit may be used in addition to the second operation unit 300 as the seventh or eighth embodiments to the fifth embodiment.

<Tenth Embodiment>

Fig. 11 is a hydraulic pressure circuit diagram showing a

hydraulic drive apparatus 100 which is a tenth embodiment of the invention.

An arrangement of the hydraulic drive apparatus 100 of this embodiment will first be described.

5 The arrangement of the hydraulic drive apparatus 100 of the embodiment is substantially the same as of the hydraulic drive apparatus 100 of the ninth embodiment except its arrangement to be described hereunder.

10 In the hydraulic drive apparatus 100 of the embodiment, the pressure control valve 140 consists of an electromagnetic relief valve 141.

15 The hydraulic drive apparatus 100 of the embodiment includes a pressure adjust signal output circuit 220E as pressure adjust signal outputting means. The pressure adjust signal output circuit 220E receives a pressure adjust signal outputting means through a signal transmission path, not shown, from the pressure sensor 131, drive oil pressure signals through a signal transmission path, not shown, from the pressure sensors 132 and 133, and an operation position signal through the signal transmission path 161 from the first operation lever 210, and an operation position detect signal through a signal transmission path (not shown) from the pressure sensor 134. The pressure adjust signal output circuit 220E judges, by the operation

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position detect signal input thereto, whether the second operation unit 300 drives and rotates the second hydraulic motor 301 or stops the rotation of it. When the second operation unit stops the rotation of the second hydraulic motor 301, the pressure adjust signal output circuit computes a pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by use of the input supplying-oil pressure signal and the drive oil pressure signal. And the pressure adjust signal output circuit generates a pressure adjust signal which causes the pressure control valve 140 to adjust the set pressure of the pressure control valve 140 so that the set pressure of the pressure control valve 140 is a predetermined pressure (20kg/cm^2 in this instance) higher than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201. When the second operation unit 300 drives and rotates the second hydraulic motor 301, the pressure adjust signal output circuit generates a pressure adjust signal which causes the pressure control valve 140 to adjust the set pressure of the pressure control valve 140 so that the set pressure is a predetermined pressure, e.g., 350kg/cm^2 in this embodiment. It outputs the generated pressure adjust signal to the pressure control valve 140.

While the hydraulic drive apparatus 100 of the ninth embodiment includes the flow control valve 190, the hydraulic

drive apparatus 100 of this embodiment includes a flow control valve 191, which can more reliably stop the flow of the working oil when comparing with the flow control valve 190 of the ninth embodiment.

5 An operation of the hydraulic drive apparatus 100 of this embodiment will be described.

10 The operation of the hydraulic drive apparatus 100 of this embodiment is substantially the same as of the hydraulic drive apparatus 100 of the ninth embodiment except its operation to be described below.

 For the operation, the first case of the hydraulic drive apparatus will first be described.

15 In the first case, in the ninth embodiment, the oil quantity adjust signal output circuit 220D sets the quantity of the working oil flowing through the flow control valve 190 to be 5% of the quantity of the working oil necessary for driving and rotating the first hydraulic motor 201. In this connection, in this embodiment, the oil quantity adjust signal output circuit 220D stops the flow of the working oil through the flow control valve
20 191.

 In the first case, a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is set to be higher than of the working oil necessary for driving and

rotating the first hydraulic motor 201 by 20kg/cm² or lower.

Description will be given about an operation of the hydraulic drive apparatus to set a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to be higher than of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower.

The operation position signal is input to the pressure adjust signal output circuit 220E via the signal transmission path 161.

The operation position detect signal is input to the pressure adjust signal output circuit 220E via a signal transmission path, not shown. The supplying-oil pressure signal is input to the pressure adjust signal output circuit 220E via a signal transmission path, not shown. The drive oil pressure signal is input from the pressure sensors 132 and 133 to the pressure adjust signal output circuit 220E via a signal transmission path, not shown.

The pressure adjust signal output circuit 220E judges, by the input operation position signal and the input operation position detect signal, that the second operation unit 300 stops the rotation of the second hydraulic motor 301. The pressure adjust signal output circuit computes a pressure of the working oil for driving and rotating the first hydraulic motor 201 by use of the input supplying-oil pressure signal and the input drive

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oil pressure signal, as the pressure adjust signal output circuit 220B does so in the first case in the fifth embodiment. And it generates a pressure adjust signal for causing the pressure control valve 140 to adjust the set pressure thereof so that the set pressure is 20kg/cm² higher than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201.

The pressure adjust signal is thus generated and output to a signal transmission path 165, and then to the pressure control valve 140 via the signal transmission path 165. That is, the pressure adjust signal is input to the electromagnetic relief valve 141. Upon receipt of the pressure adjust signal, the electromagnetic relief valve 141 adjusts the set pressure in accordance with the input pressure adjust signal, and adjusts the pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to be the set pressure or lower.

In this way, in the first case, the pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is set to be higher than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201 by 20kg/cm² or lower.

For the operation, the second and third cases will be described.

In those cases, the pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is 350kg/cm^2 or lower. An operation of the hydraulic drive apparatus to set the pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 to be 350kg/cm^2 or lower will be described.

As referred to in the description of the first case, the operation position signal, the operation position detect signal, the supplying-oil pressure signal and the drive oil pressure signal are input to the pressure adjust signal output circuit 220E.

The pressure adjust signal output circuit 220E judges, by the input operation position signal, that the second operation unit 300 drives and rotates the second hydraulic motor 301, generates a pressure adjust signal to set the set pressure of the pressure control valve 140 to 350kg/cm², and inputs the generated pressure adjust signal through the signal transmission path 165 to the pressure control valve 140.

Accordingly, in the second and third cases, a pressure of the working oil supplied from the hydraulic pump 102 to the first control valve 250 is the set pressure of the pressure control valve 140 or lower, viz., 350kg/cm² or lower.

In the embodiment, in the first case, the set pressure of the pressure control valve 140 is 20kg/cm² higher than the pressure

of the working oil necessary for driving and rotating the first hydraulic motor 201. The predetermined pressure may take any other value than 20kg/cm^2 if it is substantially free from the wasting of the drive horsepower of the hydraulic pump 102. In the second and third case, the set pressure of the pressure control valve 140 is 350kg/cm^2 . It may take any other value than 350kg/cm^2 if it is sufficiently larger than the pressure of the working oil necessary for driving and rotating the first hydraulic motor 201.

<Eleventh Embodiment>

Fig. 12 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100, which is an eleventh embodiment of the invention.

While the pressure control valve 140 in the hydraulic drive apparatus 100 of the tenth embodiment consists of the electromagnetic relief valve 141, the pressure control valve 140 in the hydraulic drive apparatus 100 of the present embodiment includes a main relief valve 142 and an electromagnetic relief valve 143. The remaining arrangement of the hydraulic drive apparatus of this embodiment is substantially the same as of the hydraulic drive apparatus 100 of the tenth embodiment.

An operation of the hydraulic drive apparatus 100 of this embodiment is substantially the same as of the hydraulic drive apparatus 100 of the tenth embodiment.

<Twelfth Embodiment>

Fig. 13 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100 which constitutes a twelfth embodiment of the invention.

5 An arrangement of the hydraulic drive apparatus 100 of this embodiment will first be described.

10 An arrangement of the hydraulic drive apparatus 100 of this embodiment is substantially the same as of the hydraulic drive apparatus 100 of the ninth embodiment except its arrangement to be described hereunder.

15 The hydraulic drive apparatus 100 of the embodiment includes an additional hydraulic motor 401 provided between the oil passage 125 and the tank 101. The additional hydraulic motor 401 is driven and rotated by the working oil supplied from the hydraulic pump 102 by way of a route of the oil passage 112, 118 and 119, second control valve 350, and the oil passage 125, 181 and 182, and the oil passage 183 or 184.

20 The hydraulic drive apparatus 100 of the embodiment includes additional operation unit 400, which also includes an additional operation lever 410 as additional operation position inputting means to which an operation position is input, and an additional control valve 450 which allows the working oil supplied from the hydraulic pump 102 to the additional hydraulic motor 401 to flow

therethrough, adjusts a quantity of the working oil flowing through the additional control valve in accordance with the operation position input to the additional operation lever 410, and adjusts, by the adjustment, a quantity of the working oil supplied from the hydraulic pump 102 to the additional hydraulic motor 401, whereby the additional hydraulic motor 401 is driven and rotated in accordance with the operation position input to the additional operation lever 410.

The oil passages 181 and 182 intercommunicate with each other through the check valve 171. A rotation of the additional hydraulic motor 401 is reduced in speed by the speed reduction means 402 and then transmitted to the load 403. The working oil having driven and rotated the additional hydraulic motor 401 passes through the oil passage 183 or 184, and passes again through the additional control valve 450, and returns to the tank 101 via the oil passage 185. Of the working oils passing through the oil passage 125, the working oils other than the additional hydraulic motor 401 passes through the additional control valve 450 and the oil passage 186, and are fed again to the tank 101.

The additional control valve 450 is arranged such that it adjusts a quantity of the working oil therethrough. Accordingly, an operation position input to the additional operation lever 410. To be more specific, the additional operation lever 410 is

arranged such that it supplies an operation oil that is dependent in amount on an operation position input thereto. The additional control valve 450 is arranged such that it receives the operation oil through the operation oil passage 411 or 412 from the additional operation lever 410, and adjusts a quantity of the working oil flowing therethrough in accordance with a quantity of the operation oil supplied thereto.

The pressure sensor 135 as operation position detecting means detects the operation position input to the additional operation lever 410. To be more specific, the pressure sensor 135 detects a pressure of the operation oil supplied from the additional operation lever 410 to the additional control valve 450 by detecting a pressure of the operation oil, which is higher of those oils passing through the operation oil passage 411 or 412.

In the ninth embodiment, oil quantity adjust signal output circuit 220D judges, by the input operation position detect signal, that the second operation unit 300 drives and rotates the second hydraulic motor 301. In connection with this, in this embodiment, the oil quantity adjust signal output circuit 220D judges, by the input operation position detect signal, that one of the second operation unit 300 and the additional operation unit 400 drives and rotates either of the second hydraulic motor 301 and the

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additional hydraulic motor 401. Also in the ninth embodiment, the oil quantity adjust signal output circuit 220D judges, by the input operation position, that the second operation unit 300 stops the rotation of the second hydraulic motor 301. In this connection, in this embodiment, the oil quantity adjust signal output circuit 220D judges, by the input operation position detect signal, that the second operation unit 300 and the additional operation unit 400 stop the rotation of the second hydraulic motor 301 and the additional hydraulic motor 401, respectively.

An operation of the hydraulic drive apparatus 100 of this embodiment is substantially the same as of the hydraulic drive apparatus 100 of the ninth embodiment except that the additional hydraulic motor 401 is operated.

In the hydraulic drive apparatus 100 of the hydraulic drive apparatus 100 of this embodiment, it is impossible to simultaneously operate the second hydraulic motor 301 and the additional hydraulic motor 401.

<Thirteenth Embodiment>

Fig. 14 is a hydraulic pressure circuit diagram showing a hydraulic drive apparatus 100 which forms a thirteenth embodiment of the present invention.

An arrangement of the hydraulic drive apparatus 100 of thirteenth embodiment will first be described.

The arrangement of the hydraulic drive apparatus 100 of the embodiment is substantially the same as of the hydraulic drive apparatus 100 of the seventh embodiment in the following point.

While the oil passage 181 of the hydraulic drive apparatus 100
5 communicates with the oil passage 125 in the twelfth embodiment, the oil passage 181 of the hydraulic drive apparatus 100 communicates with the oil passages 119 in the thirteenth embodiment.

10 An operation of the hydraulic drive apparatus 100 of this embodiment will be described.

The operation of the hydraulic drive apparatus 100 of the embodiment is substantially the same as of the hydraulic drive apparatus 100 of the twelfth embodiment except that it is impossible to simultaneously operate the second hydraulic motor
15 301 and the additional hydraulic motor 401.